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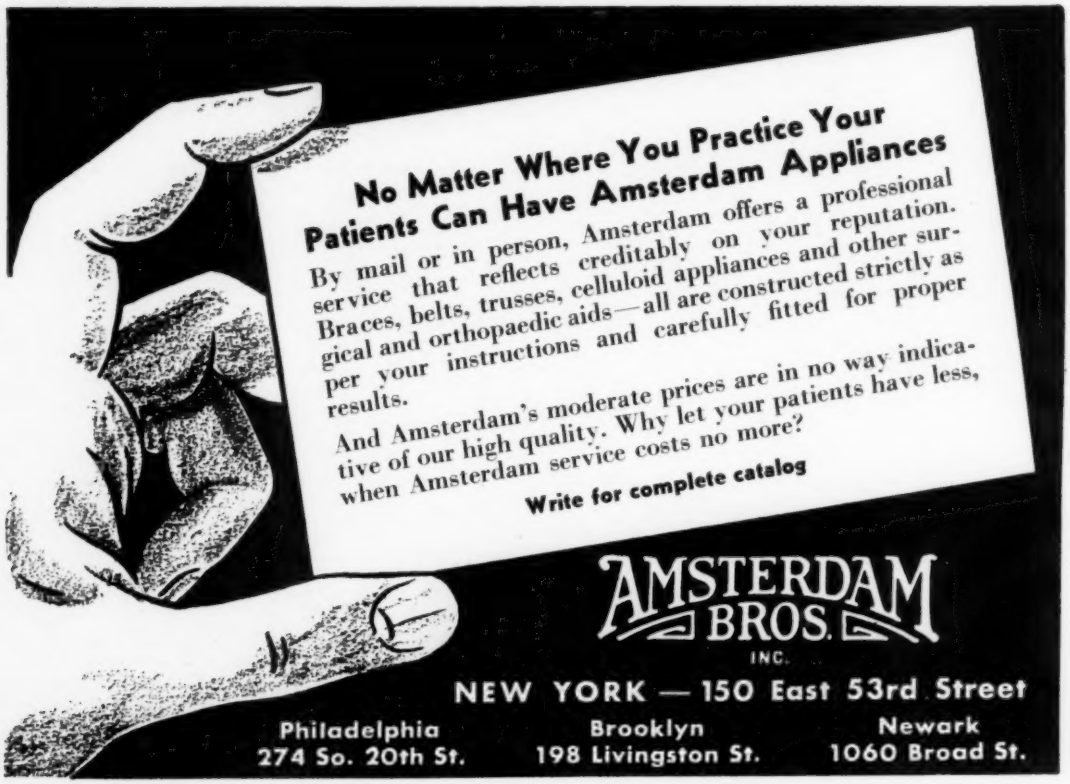
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The Journal of Bone and Joint Surgery

THE FIRST STAGES OF COXA PLANA *

BY HENNING WALDENSTRÖM, M.D., STOCKHOLM, SWEDEN

In 1909, Legg and also the author described a hitherto unknown deformity of the hip. In 1910, Calvé and then Perthes described the same thing. Our observations have all proved to be correct except in regard to the etiology of the disease,—each of us expressed a different opinion, but none of us was right. The etiology of the disease is still an unsolved problem. Among the various names that have been given to it, "Perthes' disease" and "osteochondritis deformans" are the most common. The former is badly chosen, however, as Perthes was not the first to describe the disease. The latter is equally unfortunate, as it conveys a wrong idea: the disease is not inflammatory—that is, it is neither an osteitis nor a chondritis. In 1920, therefore, the writer suggested the name "coxa plana", a term which, like "coxa vara", takes no account of the etiology, but only of the appearance of the deformity,—namely, the flattened epiphysis.

By many authors the term "coxa plana" is used as a designation merely for the later stages of the disease, because they believe that only then has the head become flattened. This is not the case, however. The studies which the author has made show that the flattening of the epiphysis is the principal sign of the pathological process in its very earliest stage. From a study of the anatomical specimens, we know that the pathological process is a primary necrosis, followed by resorption of the necrotic cancellous tissue, and, at last, formation of new bone and cartilage.

The studies on which this paper is based comprise cases of coxa plana selected from those which the author has treated personally during the last thirty years. Of these, thirteen came under his observation at so early a stage of the disease that they have enabled him to demonstrate the beginning of the coxa plana.

The first symptom of the disease is limping, sometimes associated with pain in the hip or, more commonly, toward the knee. In the beginning, these symptoms appear only after some strong exertion, and they disappear when the patient has rested a while. When the patient first comes to the doctor in this initial stage, the limping is often so slight that

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Los Angeles, California, January 19, 1938.

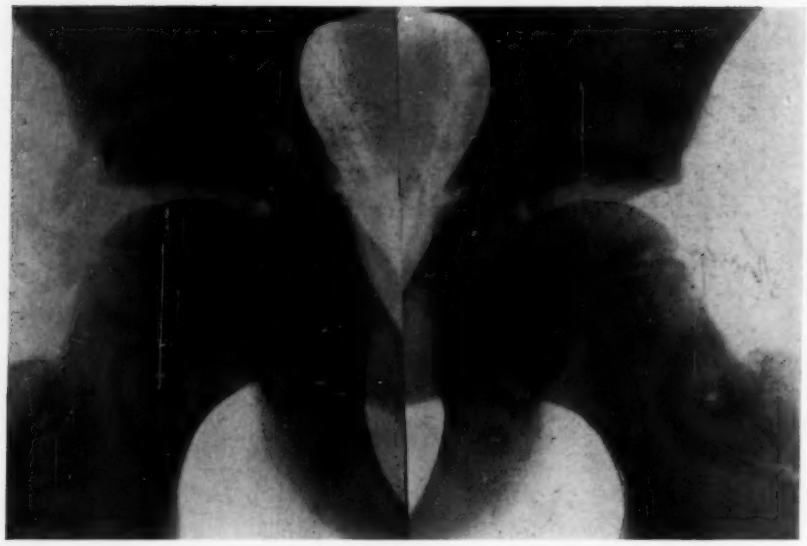

FIG. 1-A

FIG. 1-B

FIG. 1-C

M-n, a boy, aged nine years, was admitted to the hospital on September 6, 1932, with a slight limp of three months' duration.

Fig. 1-A: Roentgenogram, taken on admission, showing the epiphysis of the right femur to be lower than that of the left and flattened on its upper portion, as well as an increase in the distance between the epiphysis and the bottom of the acetabulum.

Fig. 1-B: Lateral view (Lauenstein's position), taken on admission.

Fig. 1-C: Lateral view, taken one year later.

it is not noticeable to the eye; although, when he is made to walk across the floor with his shoes on, it may often be heard. Besides the limp, there was in all the writer's cases a restriction of mobility sufficiently definite to be measured in degrees when compared with the sound hip. In the beginning this restriction of mobility very soon disappears if the patient is kept in bed.

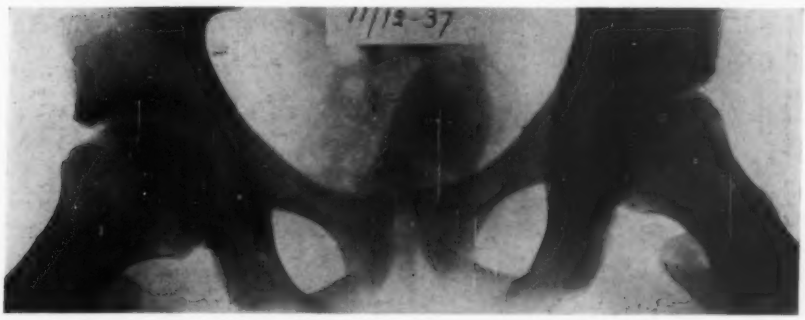

FIG. 1-D

Lateral view (Lauenstein's position), taken five years later, showing the final stage, with slight deformation of the head.

The writer has treated four cases in which the symptom of limping had been present for some weeks only. The roentgenographic appearance at that time was normal, but, as in all four cases the roentgenograms were taken in the anteroposterior direction only (at other hospitals), it may be that the lateral projection (Lauenstein's position*) might have shown some changes. All of the author's early cases prove that in the beginning the deformity is always more pronounced in the lateral view. (See Figures 1-A, 1-B, 2-A, and 2-B.) Soon, however—two or three months after the beginning of the limping—the characteristic signs of coxa plana began to be visible: that is, the normal structure of the cancellous tissue in the upper part of the epiphysis on the articular surface began to be resorbed.

The changes to be observed in the roentgenograms taken at this early stage are very slight, and a minute comparison of the two hip joints is required to discover them. Both sides have to be very carefully and symmetrically exposed on the same film. In order to make it easier for the reader to get a simultaneous view of the two hip joints, the writer has cut away the central part of the films on which the hip joints and the pelvis have been photographed symmetrically, and has placed the two joints side by side, as close to each other as possible (Figs. 1-A through 2-C). It may now be seen that the form of the two sockets is identical. If we compare the femoral epiphyses, we find that the epiphysis on the right side is lower and shows a distinct flattening of the part facing the roof of the acetabulum. In the roentgenograms taken in Lauenstein's flexion-abduction position, this flattening is still more apparent.

It will be noted that the flattening mainly involves the upper anterior part, while the lower portion has retained its normal shape. This is due to the fact that only the upper anterior part is necrotic. If we look more closely, we find at the top—that is, in the upper part of the epiphysis where it looks as if something had been worn away—a thin, hardly distinguishable line concentric with the epiphysis. This narrow strip indi-

* Taken with the femur in flexion and abduction.

FIG. 2-A

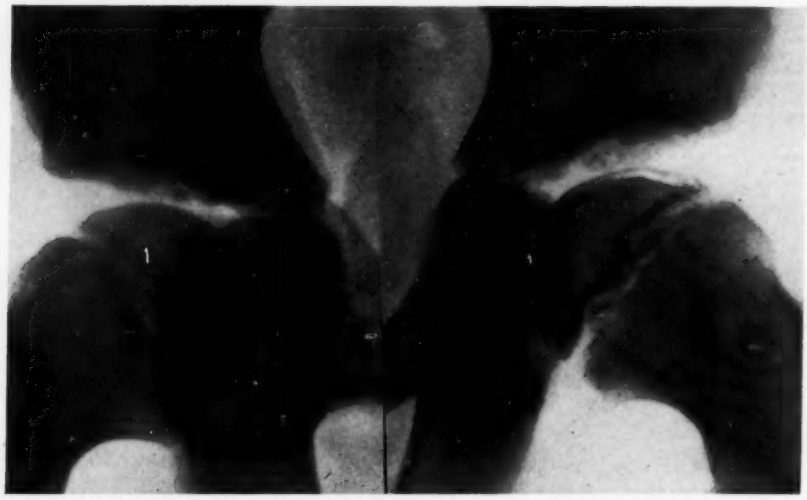

FIG. 2-B

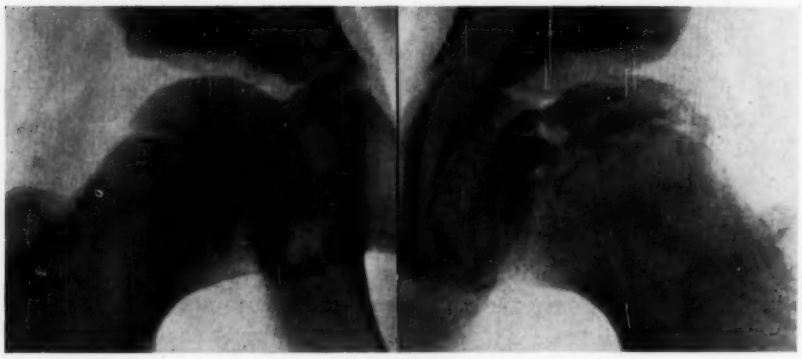

FIG. 2-C

R. E., a boy, aged seven years, was admitted to the hospital in January 1936, with a very slight limp of six weeks' duration.

Fig. 2-A: Anteroposterior view on admission.

Fig. 2-B: Lateral view on admission.

Fig. 2-C: Anteroposterior view one year later.

cates the position of the joint cartilage. It is visible in the roentgenogram only because a narrow margin of the bone has not become resorbed, and is, therefore, still in its place close to the cartilage. Underneath this strip there is a bright zone, caused by a subchondral resorption of necrotic bone. The cartilage of the joint has thus lost its natural support and has been pressed together. The necrosis may involve more or less of the epiphysis; sometimes, only the upper anterior part; and, in the most extensive cases, the whole epiphysis with the adjacent part of the neck. The necrosis never involves only the lower part of the epiphysis.

When one examines the roentgenograms of these incipient cases of coxa plana, one notices a constant change in the diseased hip joint, consisting in an increase in the distance between the femoral epiphysis and the bottom of the acetabulum or, to put it more clearly, an increase in the distance from the epiphysis to the lateral leg of the U-shaped figure. In the author's opinion, the explanation of this phenomenon is as follows: In roentgenograms of coxa plana in its first stages, the acetabulum is of normal shape and is like that of the normal hip. The cause must, therefore, be found in the head-neck portion of the femur. The muscles of the hip joint press the head against the roof of the acetabulum. Above, the head finds the firm roof of the socket; the head then moves upward and laterally. It does not fit into the socket, which can be easily seen from this increase in distance between the epiphysis and the bottom of the socket. The empty bottom of the socket is then filled with synovia, as may be seen where per-abrodil has been injected into the joint (Fig. 3-B) after aspiration of an increased volume of synovia. The increase in the distance between the epiphysis and the bottom of the socket may also be observed in another way. In roentgenograms of the hip in the antero-posterior projection, the posterior margin of the acetabulum—which is developed from the ischium—is always seen as a curved line intersecting

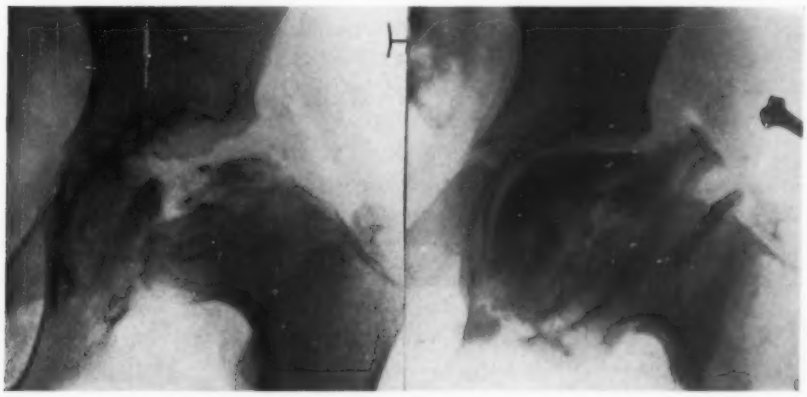

FIG. 3-A FIG. 3-B

Fig. 3-A: Coxa plana in the stage of fragmentation.
Fig. 3-B: After injection of per-abrodil (iodine contrast solution) into the capsule, showing that the enlarged space between the epiphysis and the bottom of the socket is filled with synovia and not with any tissue.

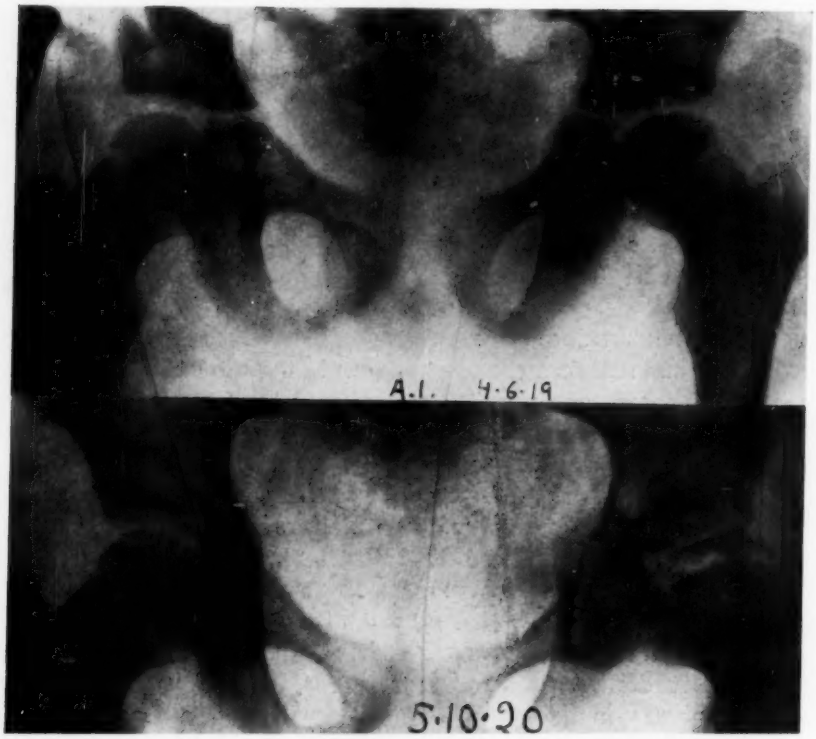

FIG. 4

A-g, a boy, aged eight years.

Fig. 4-A (*upper*): Roentgenogram, taken in June 1919, showing beginning coxa plana in the right hip joint and a normal left hip joint.

Fig. 4-B (*lower*): Roentgenogram, taken in October 1920, showing coxa plana in the stage of fragmentation on the right and a still normal hip on the left, sixteen months after the first roentgenogram had been taken.

the head in its medial part. The contact between the ischium and the head is less in the hip where the coxa plana exists than in the opposite sound hip. (See Figures 1-A, 2-A, and 2-B.)

This change in the position of the epiphysis in relation to the acetabulum was observed by Jansen, who explained it by assuming a congenital variation in the shape of the acetabulum, which he called "a wide hip socket"; according to him, this should be the cause of coxa plana. The roentgenograms which he reproduced in support of his theory, however, were from cases in which the process was too far advanced at the time they were taken to allow any hypothesis in regard to the primary or secondary nature of the changes to be based upon them. On the other hand, the writer's roentgenograms show the earliest stages of coxa plana which have as yet been published, and they permit us to conclude that at the beginning the size and shape of the socket are normal. There is no "wide hip socket" in the initial stage of coxa plana. The condition described by Jansen under that name is the result of the changed position of the

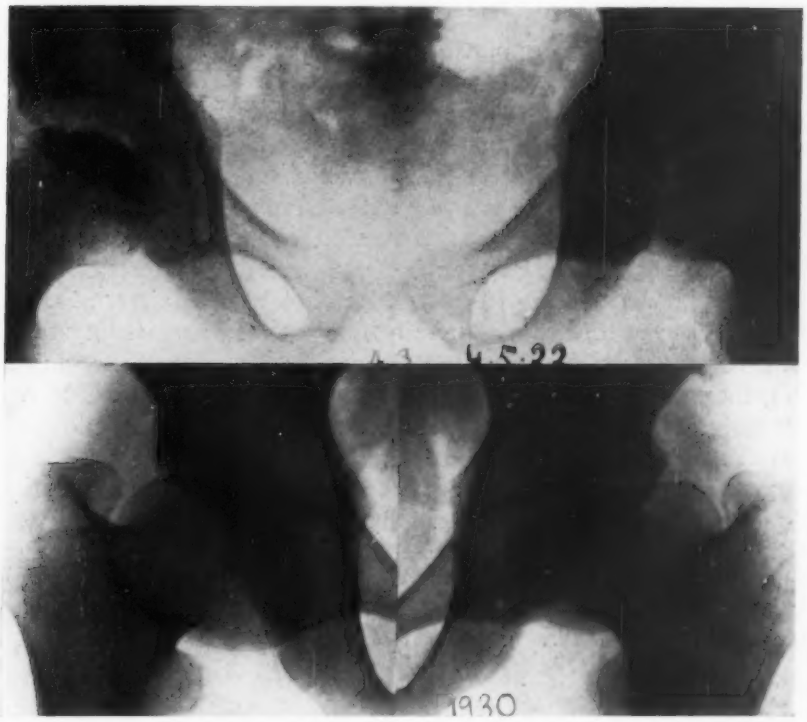

FIG. 4

Fig. 4-C (*upper*): Roentgenogram, taken in May 1922, showing coxa plana of both hip joints.

Fig. 4-D (*lower*): Roentgenogram, taken in 1930, showing the final stage on both sides: on the right, deformation of the highest degree (tap-shaped); on the left, of medium degree (mushroom-shaped or egg-shaped).

epiphysis in relation to the acetabulum; or, to express it as cautiously as possible, it is seen in the roentgenogram that the lower portion of the epiphysis is separated from the bottom of the socket, but the form of the latter remains normal. If one has seen roentgenograms of this terminal stage only, one may easily persuade oneself that the sloping roof is the primary process and the real cause of the deformation of the head. Calot made that erroneous conclusion, and called the coxa plana "*une subluxation congénitale méconnue*". When the head shrinks, it travels upward and outward in the acetabulum—that is, in the same direction as in the case of a subluxation—but these changes have nothing to do with the form of the acetabulum.

In all of the author's cases of coxa plana, the distance between the epiphysis and the bottom of the acetabulum has always been increased no matter how small the changes in the epiphysis. The question now arises: What was the condition before the beginning of the coxa plana? The only possible way of solving this problem, as far as the writer can see, is by means of roentgenograms of the hip taken a long time (not less than

a year) before there are any symptoms from the joint, and by additional roentgenograms showing typical signs of coxa plana. That possibility exists only in cases where the process is bilateral. Therefore, the writer has gone through his material and has picked out the bilateral cases for a careful study. Among them there were three which answered the claims that have been proposed. The joint of the opposite side was normal in all cases. In all of these previously normal hip joints, a coxa plana developed a long time (more than a year) afterward. Coxa plana thus arises in a joint primarily normal.

Although the subject of *treatment* is not strictly within the limits of this paper, the author cannot refrain from warning against any radical operative procedure. In the beginning, coxa plana always shows in the roentgenogram only very slight lesions. The deformation of the head may be insignificant or marked, and no prediction can be made in this regard before the stage of fragmentation has set in,—that is to say, about one year after the beginning of the slight limping. Then one can see whether or not the necrosis of the epiphysis, and sometimes of the adjacent portion of the neck, is going to be extensive. If anything is to be done, it should be done before this period. It should be remembered that most cases heal with a deformity which is only slightly troublesome, at least up to fifty years of age. It is important, therefore, never to use any operative treatment, with the possible exception of drilling through the epiphyseal cartilage. The writer is not able to say whether or not this procedure is of any benefit, as he has used it in only a few instances and during a very short time.

The most important consideration is to treat these cases purely conservatively. The patients should be given from one to two months' rest in bed, after which they may be up and about on crutches for at least one year. It is necessary for most patients to stay at the hospital for one month in order to learn to walk with crutches. If any contracture develops, extension with adhesive tape is used until the contracture disappears; this usually requires from one to two months.

Plaster and immobilizing bandages should never be used. All such procedures tend to impair the circulation and nutrition in the joint and may, therefore, be injurious.

NOTE: After this paper had been presented, Dr. Murray S. Danforth, of Providence, Rhode Island, was kind enough to show the author his roentgenograms of patients who were treated with rest in bed for one year or more and then were allowed to walk with crutches. The writer thinks that Dr. Danforth's results in two cases were better than those which he obtained and he is now going to try this method of treatment.

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THE RESULTS OF POSTURAL REDUCTION OF FRACTURES OF THE SPINE *

BY R. WATSON-JONES, F.R.C.S., M.CH.ORTH., LIVERPOOL, ENGLAND

Fractures of the spine include injuries to the vertebral bodies and the interarticular joints, avulsion fractures of the transverse processes, and contusion fractures of the spinous processes. This investigation concerns only the first of these groups of injuries.

TYPES OF VERTEBRAL-BODY FRACTURES

Three types of vertebral-body fractures are to be distinguished: (1) simple wedge fracture; (2) comminuted fracture; and (3) fracture-dislocation. (See Figures 1-A, 1-B, and 1-C.)

Simple Wedge Fracture

Wedging of vertebrae is due to a diffuse bending force with vertical compression, and, as a rule, more than one vertebral body is involved. The reduction in the anterior depth with forward bulging of the cortex at the upper or lower angles is often obvious in two, three, four, or even

FIG. 1-A FIG. 1-B FIG. 1-C

Three types of flexion compression fractures of vertebral bodies.

Fig. 1-A: Simple wedge fracture by diffuse bending or vertical compression; several bodies are involved; the discs are normal; ankylosis is rare. (151 cases.)

Fig. 1-B: Comminuted fracture by acute angulation; one body only is involved; the disc is ruptured; ankylosis is common. (33 cases.)

Fig. 1-C: Dislocation of the intervertebral joint with fracture of the neural arch; the cord is compressed or severed; there is a secondary fracture of the body below. (68 cases.)

* Read in abstract at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Los Angeles, California, January 19, 1938.

five vertebrae in the initial roentgenogram. In other cases, the obvious injury appears to be confined to one vertebra, but actual measurement of the roentgenograms shows slight diminution of the anterior depth of the bodies above and below. There is no fracture of the pedicles or of the laminae, and forward tilting of the bodies is possible only through movement of the interarticular joints. Since several vertebrae are involved, no one interarticular joint is actually dislocated, but several may be strained.

Comminuted Fracture

This fracture is due to more acute and localized injury. There is such sharp angulation at one intervertebral-disc level that the anterior angle of one of the vertebral bodies is driven into the middle of the adjacent body. Even if the spine has been partly extended again, the triangular-shaped depression of the intervertebral surface of the fractured body corresponds so exactly in size and shape to the angle of the adjacent vertebra that the mechanism of injury is obvious. (See Figure 5-D.) Occasionally both upper and lower surfaces of the fractured body are similarly depressed; the vertebra above and the vertebra below have almost met in the middle, and anterior marginal fragments may have been squeezed forward. (See Figure 7.)

FIG. 2-A

FIG. 2-B

Spontaneous fracture of the spine in senile osteoporosis.

The angle of the impacting vertebral body has frequently impaled and ruptured the intervening disc, forcing it between the bony fragments. Narrowing of the intervertebral-disc space is seen more commonly in this than in any other type of fracture of the spine. With an injury so localized, one or perhaps two interarticular joints take the whole strain of the displacement, and the interarticular-joint injury is even more serious than in simple wedge fractures. Nevertheless, persistent pain is less common in unreduced comminuted fractures, because the rupture of the intervertebral disc promotes bony ankylosis between adjacent vertebral bodies, a sequela which is rarely seen in wedge fractures.

Fracture-Dislocation

This injury is primarily an intervertebral dislocation, with trauma to the neural arch, which allows the upper segment of the spine to dislocate forward. The displacement is such that the spinal cord is compressed, attenuated, or severed. The neural-arch injury may be a bilateral dislocation of the interarticular joints, a bilateral fracture of the laminae or of the pedicles, or a combination of these injuries. As the upper segment of the spine displaces forward, the vertebral body below may be secondarily wedged or comminuted, or a fragment may be detached from its upper margin.

An investigation of 252 vertebral-body fractures shows that simple wedging of one or more vertebrae is the most common injury, and comminuted fracture is the most rare.

Type	*No. of Cases*	*Per Cent.*
Simple wedge fracture	151	60
Comminuted fracture	33	13
Fracture-dislocation	68	27
Total	252	100

ETIOLOGY OF VERTEBRAL-BODY FRACTURES

All three types of fractures are due to hyperflexion and compression strains.

Type of Accident	*No. of Cases*	*Per Cent.*
Patient fell from a height	146	58
Weight fell on the patient	45	18
Motor-car accident	33	13
Other mechanism (or unknown)	28	11
Total	252	100

The classic accident is the fall of a weight on the back of the patient's shoulders. This produces acute flexion of the spine, and is usually responsible for comminuted fractures and fracture-dislocations. Less than one-quarter of the cases in this series were of this type, and most of these patients were coal miners, the victims of falling roofs.

The simple wedge fractures are more often attributable to vertical

compression of the spine, due to a fall on the feet or on the buttocks. The industrial activities of a large city may explain the frequency of falls from a height. In smaller towns, close to arterial roads, a higher proportion would no doubt occur from motor accidents. More than half of the patients in this series fell from scaffolding, from cranes, from ships' sides and ships' decks, from ladders, and from roofs. Some fell in the standing position,—as, for example, the sailor who fell down the inside of a ship's mast and also fractured both heels. Routine examination of the spines of patients who have sustained a crush fracture of the os calcis has on several occasions disclosed an unsuspected wedge fracture of the vertebrae. Some patients fell on the buttocks in the sitting position, like the two victims of an aeroplane crash who sat one in front of the other in the cockpit; both sustained fractures of the lumbar spine.

The miscellaneous group includes one case where the mechanism was the opposite of a fall in the sitting position. A girl sat on the deck of a motor launch, and an explosion beneath the deck blew her into the air, fractured her spine, and flung her forty yards into the sea. Despite complete paraplegia, she swam to a dinghy, escaped drowning, and ultimately recovered. In several cases, senile osteoporosis predisposed the patients to fractures of the spine from relatively trivial injuries. An elderly doctor was stooping to lift a moderately heavy weight when he felt a crack in his back; roentgenographic examination showed severe crushing of the fourth lumbar body. (See Figures 2-A and 2-B.)

Fractures of the cervical spine occurred more commonly from the fall of a weight on the back of the head, and from motor accidents. A woman was the passenger in a car which stopped very suddenly at a robot signal; her head was jerked forcibly forward and, although it was not struck in any way, a cervical interarticular joint was dislocated. Two men were the victims of rugby-football accidents. In both cases the players were locked in a scrummage which collapsed; their heads were forced down by the weight of other players, their cervical spines were dislocated, and both died from the complications of paraplegia.

TECHNIQUE OF REDUCTION AND IMMOBILIZATION

The series includes ninety-four personal cases treated mainly by the technique first described in 1930[4], which consists of postural reduction (without general anaesthesia) by prone suspension between two tables, the application of a plaster jacket, and early ambulatory activity. Other methods which have been employed include the heel-suspension technique of Davis[1], extension of the spine by pumping up the kidney bar of an operating table over which the patient lies supine, and pulley extension by a canvas sling on which the patient lies prone.

The various methods of reduction may be divided into two groups:

1. The trunk is wholly unsupported; the patient lies prone, and the spine sags into maximum hyperextension (Figs. 3-A and 3-B).

2. The trunk is supported in the extended position; the patient lies

prone on a canvas sling or Roger's frame[3], or supine on an extended spinal frame, curved strip of metal, kidney rest, motor jack, etc. (See Figure 4.)

Whereas in the first group of methods the unsupported trunk finds its own limit of hyperextension, in the second the surgeon determines the degree of extension and supports the trunk in that position. Is there any essential difference in the effectiveness of these methods?

FIG. 3-A

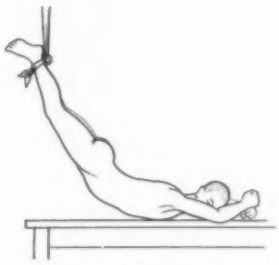

FIG. 3-B

Adequate methods of reduction. The trunk is unsupported; the pelvis tilts forward; and the lumbar spine must sag to the limit of hyperextension.
Fig. 3-A: Watson-Jones technique. Fig. 3-B: Davis technique.

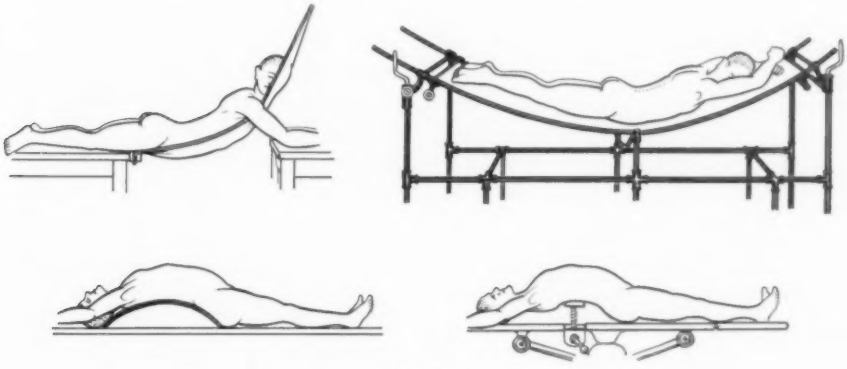

FIG. 4

Relatively inadequate methods of reduction. The trunk is supported in a controlled degree of extension. The pelvis does not fully tilt forward, and the normal limit of hyperextension is not attained.

Reduction depends on the tension of the anterior longitudinal ligament. It is not enough that the spine is extended. It must be hyperextended, and it must be hyperextended to the normal limit. Not until this limit has been reached does the anterior longitudinal ligament become sufficiently taut to complete the reduction, and, still more important, to maintain the reduction. Only if the limit is reached and maintained is it impossible for the vertebral body to collapse whether or not the patient is ambulatory.

The normal range of extension movement varies in every patient. One patient, of the short, thickset type, may have reached the limit at 20 degrees, but another patient must hyperextend the spine 60 degrees

FIG. 5-A

FIG. 5-B

FIG. 5-C

FIG. 5-D

Roentgenograms of typical cases one year or longer after adequate treatment.

Fig. 5-A: Example of multiple wedging; four vertebrae were involved. The final wedging cannot be measured. (32 per cent. of the cases.)

Fig. 5-B: Final wedging one-eighth of an inch. (36 per cent. of the cases.)

Fig. 5-C: Final wedging one-fourth of an inch. (25 per cent. of the cases.)

Fig. 5-D: Example of a comminuted fracture; the disc is ruptured; there is bony ankylosis. Final wedging more than one-fourth of an inch. (7 per cent. of the cases.)

before the ligament is normally taut. The use of any curved surface on which the patient lies, presumes that the same degree of extension will correct every fracture, and this is not so. If a motor jack or kidney rest is pumped up beneath the kyphos, the surgeon cannot know when the limit of extension has been reached. If a ventral sling or hammock is used, imperfect reduction is particularly common. The sling prevents the tight stretched feeling in the abdominal wall, but, in so doing, it has limited extension movement, prevented forward tilting of the pelvis, and interfered with complete reduction.

For these reasons, the original technique—in which the trunk is entirely unsupported from the arms to the thighs, so that it must sag into space to the limit of the patient's extension movement—is still preferred as the routine treatment for lumbar and thoracolumbar fractures. If the injury is of several weeks' duration and anaesthesia is required, the technique of Davis is more convenient. Only in high thoracic fractures, where lumbar extension is not required and where direct pressure under the kyphos is more effective, is the pumped-up kidney bar of an operating table used. At this high thoracic level, perfect reduction is difficult and sometimes impossible, whatever technique is employed.

RESULTS OF TREATMENT

Wedge and Comminuted Fractures

The personally treated cases have been reexamined and check-up roentgenograms have been taken twelve months or longer after injury. The investigation shows that in lumbar and low thoracic fractures there is no difficulty in correcting wedging and in preventing redisplacement. In two-thirds of the cases, the final wedging either cannot be measured in the roentgenograms or does not amount to more than one-eighth of an inch. In only 7 per cent. of the cases was the method so ineffectively applied that the final wedging was more than one fourth of an inch. (See Figure 5-D.) The roentgenographic findings twelve months or longer after injury in these sixty-seven personally treated cases of wedge or comminuted fractures were as follows:

Findings	*Per Cent.*
Wedging or collapse of vertebral bodies:	
Not measurable	32
One-eighth of an inch or less	36
One-quarter of an inch	25
More than one-quarter of an inch	7
Integrity of intervertebral discs:	
No narrowing of disc space	80
Narrowing of disc space	20
Spur formation at vertebral-body margins:	
None	78
Trace	20
Severe	2

FIG. 6

Wedge fracture after inadequate treatment. The discs are normal, and there is no tendency to ankylosis. There is still severe aching pain six years after injury, due to interarticular-joint strain.

FIG. 7

Comminuted fracture after inadequate treatment. Both discs have been ruptured, and there is bony ankylosis. Despite deformity, there is no pain.

Such a degree of anatomical accuracy in the results is far less evident in the 117 cases examined months or years after treatment elsewhere. (See Figures 6 to 11.) Attempts to reduce the fractures and to apply plaster jackets had sometimes been made, but wedging was the rule, not the exception. It varied in degree from reduction by one-third in the anterior depth to almost complete disappearance of the anterior margin of the body. (See Figure 6.)

Significance of Uncorrected Wedging

Does it matter if the fracture unites with wedging? Is wedging responsible for persistent pain or for any other disability? Even when the fragments have united in relatively good position, some patients complain of persistent pain. In only two-thirds of the cases in which good reduction was obtained was there complete absence of pain, with an assurance from the patient that the spine was as good as before the accident. Thirty per cent. of the patients complained of occasional discomfort or pain, and 4 per cent. complained of frequent or severe pain. But in the other series, where there was more marked deformity, almost every patient complained of considerable pain. The complaint was quite monotonous in its regularity. Many patients were seen years after injury, long after the conclusion of all medicolegal dispute, still complaining of serious pain.

There can be no doubt that severe wedging of one or more vertebrae throws the interarticular joints out of alignment and causes persistent

FIG. 8

Fracture-dislocation of spine. No attempt was made to reduce the deformity "because the patient was paraplegic". Although the paraplegia has fully disappeared, the deformity and pain are such that the patient is still totally incapacitated.

FIG. 9

Dislocation of cervical spine with nerve-root pressure. The failure in this case was due to faulty reading of roentgenograms which had been interpreted as "showing no bone injury".

FIG. 10

Fracture treated on spinal frame. Patient had been told that "one-eighth of an inch more would have meant paralysis". After twelve months of recumbency, he was told "not to walk very much", and "never to go out without his wife". He is a nervous wreck and will never work again.

painful strain. The analogy of the malunited fractured spine with the painless kyphos so often seen in healed tuberculosis is fallacious. In healed tuberculosis, the angulated area has undergone fibrous or bony ankylosis. These cases are only comparable with comminuted fractures where there is a tendency to ankylosis (Fig. 7); they are not to be compared with the more common wedge fractures which show no tendency to ankylosis (Fig. 6).

Significance of Narrowed Intervertebral Disc

Slight narrowing of the disc space is sometimes seen above or below a fractured vertebra, and this may account for a trace of kyphosis even if there is negligible wedging of the bone. The narrowing is of minimal degree and it does not appear to be an important source of pain. Serious narrowing of the disc is more common in the comminuted fracture where the disc has been ruptured by the impact of the margin of the vertebral body above. In this series there is no case of proved retropulsion of an intervertebral disc. The complication may have occasionally been responsible for local pain in the back, but there was no patient with root pain or pressure symptoms of sufficient degree to warrant complete neurological investigation.

FIG. 11

Wedge fracture imperfectly reduced and inadequately immobilized in a short plaster jacket.

Significance of Spur Formation

The formation of bony spurs at the anterior margins of vertebral bodies is only well marked in unreduced fractures. Large spurs represent unreduced fragments of the crushed vertebral body; they were present in more than half of the indifferently treated cases (Fig. 6) and in only 2 per cent. of the cases in which good reduction was obtained. Slight spur formation, due to subperiosteal ossification in the attachment of the anterior longitudinal ligament, is seen more frequently, even after accurate reduction (Fig. 5-B), but this is not a source of pain and certainly does not indicate arthritic change as is so commonly assumed.

Capacity for Work

Analysis of the subsequent history in the sixty-seven cases of wedge and comminuted fractures shows that 80 per cent. of the patients resumed

their original employment. More than half of this proportion (48 per cent.) were men engaged in heavy labor and less than half (32 per cent.) were artisans, light laborers, or sedentary workers. The other 20 per cent. maintained that they were partially or totally disabled: 8 per cent. could do light work only, and 12 per cent. could do no work. The men engaged in heavy labor were incapacitated for an average period of ten months and those in lighter employment for seven months. In most cases the plaster jacket was worn for from four to six months. It is evident, therefore, that from three to six months of treatment have been necessary after the jacket was discarded before recovery was complete.

In considering both the duration of disability and the frequency of permanent incapacity, it must be recognized that many of these patients are men past middle age, who have fallen from fifty to 100 feet and have suffered mental as well as physical injury. For example, one workman is classified with the 12 per cent. who were totally incapacitated, because, after a few weeks at work, he refused to go into dangerous situations. Consequently, he was discharged and has been unemployed ever since. He admits that, apart from occasional slight pain, his recovery is complete, but he is afraid of sustaining an even worse accident. It is probable that both the duration of incapacity and the frequency of permanent incapacity could be reduced by treatment in rehabilitation centers.

Fracture-Dislocations with Paraplegia

In the personally treated series there were twenty-seven fracture-dislocations with paraplegia. Of the nine patients with cervical injuries, three recovered; of the five patients with high thoracic injuries, only one recovered; and of the thirteen patients with lumbar and thoracolumbar injuries, eight recovered. This small series suggests that the prognosis is bad in high thoracic fracture-dislocations, but that in lumbar and cervical injuries recovery may be anticipated in about half of the cases. The outlook is obviously most favorable in injuries below the first lumbar level.

The cord damage may have been sustained at the moment of injury, or at any subsequent time that the patient was lifted by the shoulders and hips. (See Figure 12.) The danger of this movement, especially with the patient supine, was first pointed out by the author in 1931.[4] When a patient is to be lifted onto a stretcher, or from a stretcher to a bed, special precaution must be taken to avoid flexion of the spine. If, as in coal mines, the victim must be carried a considerable distance without a stretcher or other support, face-down transportation is advisable. (See Figure 13.) It is actually much easier to carry a helpless patient prone than supine, and the Swahili negroes have carried their victims of spinal injury in this way for many generations.

It is probable that the fate of the spinal cord is already sealed by the time the patient is lying flat in bed. Merely laying the victim on a flat surface has usually reduced the dislocation sufficiently to relieve actual

FIG. 12

If a patient with a thoracolumbar fracture-dislocation is carried face upward, the spine is forced into flexion and the injury must be increased.

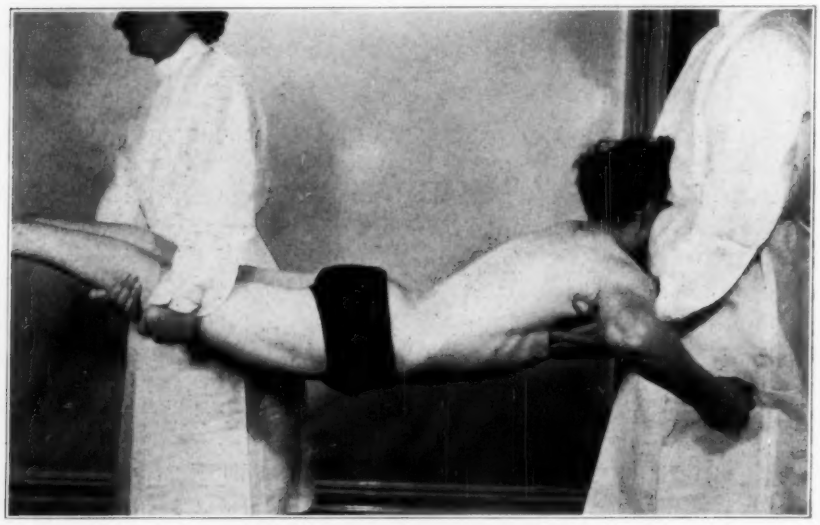

FIG. 13

When no stretcher is available, face-down transportation is *relatively* safe.

bony pressure on the cord, so that the Queckenstedt test shows no obstruction to the free circulation of cerebrospinal fluid. If this flat position could be maintained uninterruptedly, it would probably be true to say that recovery from the paraplegia could not be promoted still further by hyperextension of the spine, which completes the last stages of reduction. However, it cannot be maintained. The demands of nursing are such that the patient is continually lifted, twisted, and turned. Under these

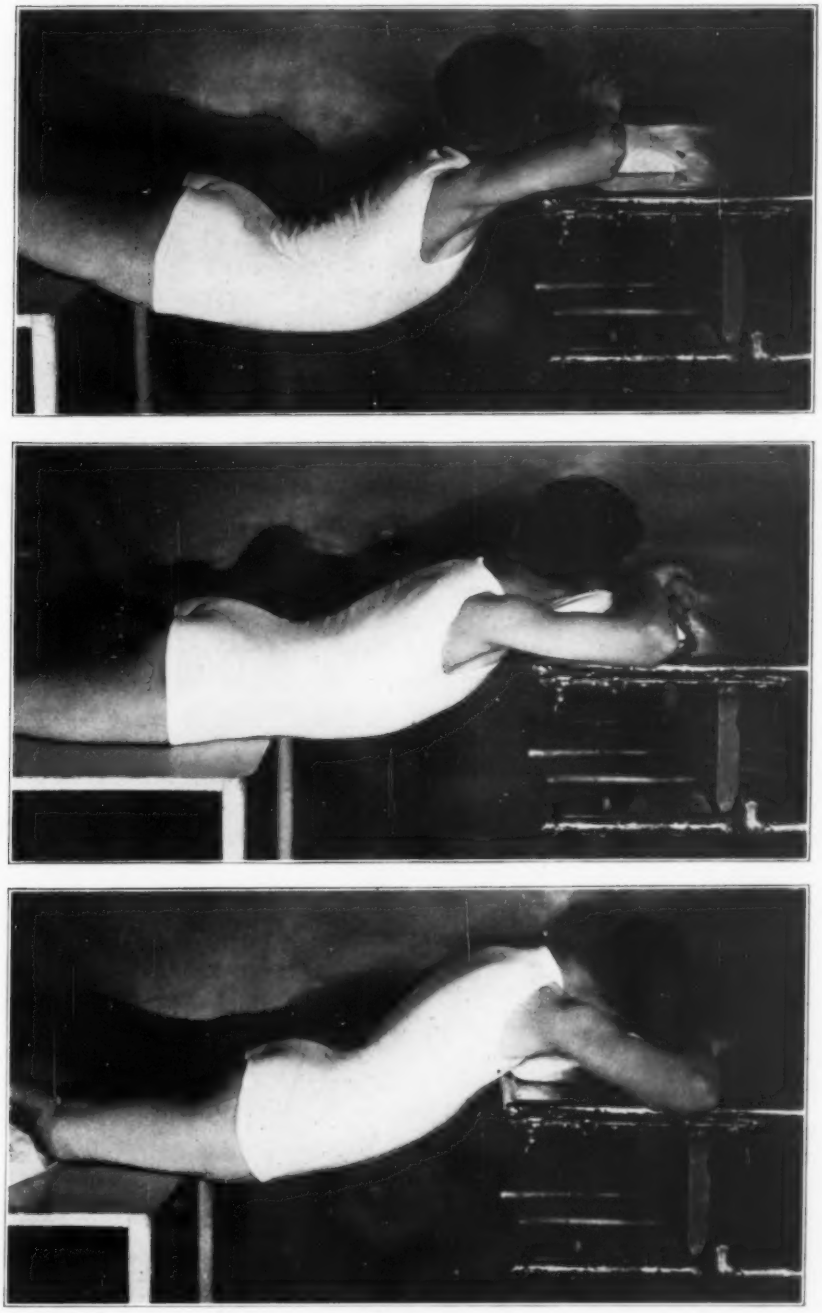

FIG. 14

Upper: Correct position for postural reduction.
Middle: Incorrect position. The lower table extends beyond the groins and prevents the pelvis from tilting forward. The lumbar spine is incompletely extended.
Lower: Incorrect position. The patient is too close to the upper table. The thoracic spine is incompletely extended and the jacket cannot be carried high enough. Displacement will recur.

circumstances, increase in the deformity and aggravation of the local injury are inevitable. (See Figure 8.) Nursing is greatly facilitated, the liability of the formation of pressure sores is minimized, and pain is relieved by immobilization in a plaster bed or anterior plaster lid. If the spine is extended, cord pressure is controlled with far greater certainty than by laminectomy, and the necessary steps have been taken to ensure a painless undeformed spine if the patient should be fortunate enough to recover from the paraplegia.

COMMON SOURCES OF FAILURE IN TREATMENT

It is becoming increasingly rare to find fractures of the spine in which no attempt has been made to correct the displacement because the injury was overlooked in the roentgenograms (Fig. 9) or because the surgeon was unfamiliar with the method. However, although in most cases plaster fixation has been employed, it is still very common to find incomplete reductions and very imperfect results. (See Figures 10 and 11.) The postural method of reduction and plaster fixation is so simple that there is some danger of ignoring the details which make all the difference between success and failure.

Many fractures have never been reduced. Although a plaster jacket has been applied, the spine has not first been fully hyperextended. Common sources of error are shown in Figure 14. If the lower table extends any higher than the thighs, the pelvis is supported and its forward tilt is minimized. In this event, the lumbar spine is imperfectly extended; either the fracture will be incompletely reduced or displacement will recur within a few weeks. Similarly, if the higher table is placed too close to the chest, the thoracic spine is incompletely extended, and the plaster jacket cannot be carried up to the clavicles. A plaster jacket applied in this position will inevitably permit redisplacement when the patient is allowed up.

FIG. 15

Correctly applied plaster cast, extending from the groins and the symphysis pubis to the clavicles. The lumbar spine cannot be flexed.

FIG. 16

Incorrectly applied plaster cast. It is cut too high at the groins and too low over the chest. Displacement of the fracture will recur.

Figure 15 shows a perfectly applied plaster cast. It extends from the symphysis pubis and the groins up to the clavicles. In this cast it is impossible to flex the spine, and displacement cannot recur whether or not the patient is ambulatory and practising exercises. If the patient complains that when he sits, or lies in bed, the plaster digs into the groins or presses in the neck, the surgeon must not cut away plaster until he can sit comfortably (Fig. 16); he must teach the patient how to sit and to lie, propped with pillows, so that he extends the trunk away from the plaster margins. The surgeon who was so kindhearted as to cut the plaster as generously as shown in Figure 17 should have been honest with himself and should have removed it altogether. The jacket is so short in front that it is not immobilizing the spine at all. Furthermore, the large abdominal window was cut before the plaster was hard, and the final result is that the patient can flex his spine almost as freely as if he were not in plaster at all (Fig. 18).

In other cases, far too much wool and felt protection has been used beneath the plaster. Even if the jacket is applied over a single layer of stockinet with a square of adhesive felt over the kyphos, it becomes very loose within a few weeks. In many cases a new jacket must be applied, again in the position of maximum hyperextension, from four to eight weeks after the original reduction.

Finally, in many cases, excellent primary treatment has been wasted because the jacket has been removed too soon. Crush fractures of verte-

FIG. 17

A plaster jacket which is a pure ornament. It is not immobilizing the spine at all.

FIG. 18

The patient can flex the spine almost as freely as if he were not in plaster at all.

bral bodies are slow in consolidating, and it is unsafe to allow flexion movement in less than four months. The comminuted fractures are particularly slow in uniting, and in these cases the jacket should be retained for six months. It is a mistake to use a posterior spinal support at any stage of treatment. In early months it gives the surgeon a false sense of security. However well made and however heroically worn, a posterior support cannot prevent collapse of an unsoundly consolidated fracture. In later months it gives the patient a false sense of security. Many months or even years may elapse before he can be persuaded to discard a splint which is doing nothing except preventing him from stretching adhesions.

HYPEREXTENSION FRACTURES

In 1934 the author described the first recorded case of hyperextension fracture of a lumbar vertebral body.[4] The intervertebral ligaments withstood the extension strain and remained intact; the vertebral body was comminuted; an upper anterior quadrant was tilted upward by the traction of the ligament above and a lower anterior quadrant tilted downward by the traction of the ligament below. Since that time, only one other hyperextension fracture has been seen, and this was of a different type.

FIG. 19

Hyperextension fracture of both pedicles sustained spontaneously by an acrobatic dancer.

An acrobatic dancer had taken up her profession at such a late age that it was always necessary for her to spend from ten to fifteen minutes loosening and "limbering" before going on to the stage. One night she was called on hurriedly. In the course of the dance she slowly hyperextended her spine until her head was almost between her knees. There was an ominous crack and an agonizing pain; she had fractured both pedicles of the neural arch of the first lumbar vertebra (Fig. 19). Despite immobilization in plaster for many months, the fractured pedicles failed to unite by bone. A firm fibrous union developed. The patient pursues all normal recreations without symptoms and still has more than normal mobility of the spine, but she has not resumed professional dancing.

These two cases are the only known exceptions to the rule that lumbothoracic fractures are produced by hyperflexion and must be reduced and immobilized in hyperextension. There is, however, a type of lumbar fracture-dislocation in which caution is necessary because the articular processes are locked.

LUMBAR FRACTURE-DISLOCATION WITH LOCKING OF ARTICULAR PROCESSES

When an intervertebral joint is dislocated, the upper segment of the spine can move forward because there is also a neural-arch injury. This may be a fracture of the base of the articular processes, a dislocation of the interarticular joints, or a combination of these injuries. If either articular process is fractured, the bones usually slide comfortably into position when the spine is hyperextended, and reduction offers little difficulty. If both interarticular joints are dislocated and there is no lateral shift or rotation of the upper segment, there may again be little or no difficulty in reducing by simple hyperextension. On the other hand, if the upper segment of the spine has not only slid forward but also to one side, the descending articular process of the upper vertebra is now actually locked in front of the ascending process of the lower vertebra on that side. (See Figure 20.) If the spine is hyperextended without first correcting the lateral shift, the upper articular process cannot slide back. The spine hinges backward, pivoting on the articular process; the vertebral bodies separate from each other; the intervertebral space is unduly widened; and the cord injury may be increased by stretching and attenuation. (See Figure 21.)

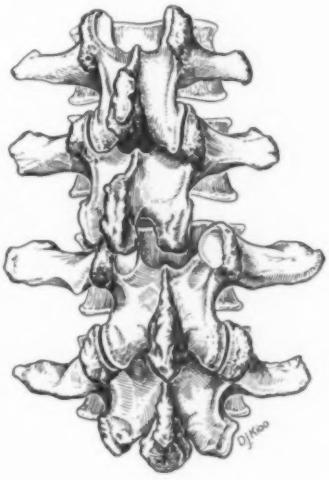

FIG. 20

The upper articular processes slip forward and laterally; the lateral shift is responsible for locking with the lower articular process on one side.

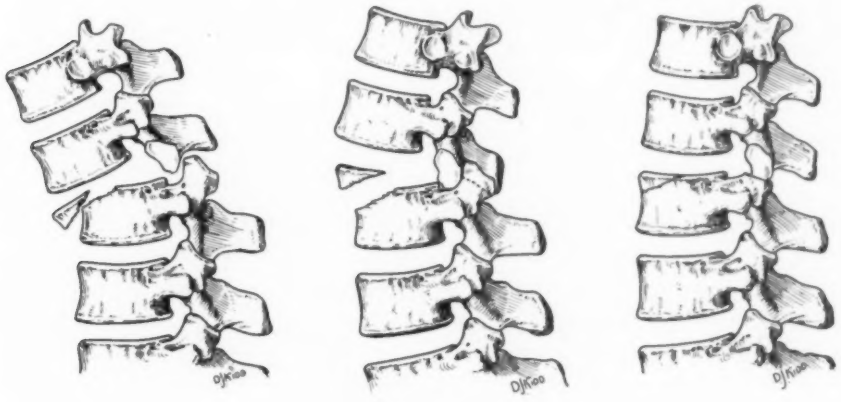

FIG. 21

Lumbar fracture-dislocation with locking of the articular processes. If the spine is hyperextended, the upper processes cannot slide backward, the spine pivots on the articular process, the vertebral bodies are separated, and the cord damage may be increased by stretching.

FIG. 22-A

FIG. 22-B

The upper articular process of the lower vertebra on the side toward which the upper segment of the spine has moved must be excised before the spine is extended.

FIG. 23

The same case as shown in Figs. 22-A and 22-B. The spine has been hyperextended without first excising the articular process. The dislocation has not been reduced, and the cord injury has probably been increased by attenuation.

Before the spine is hyperextended, it is essential to expose the lamina and articular process of the vertebra below the dislocation, on the side toward which the upper spinous processes are deviated (by lateral shift or by rotation). The articular process is unduly prominent and it must be removed as close to its base as possible. The dislocation is then easily reduced by hyperextension because there is no longer any obstruction to the descending articular process of the upper vertebra; it can then slide backward and toward the mid-line.

The decision that operative treatment is essential must be made not only on the lateral roentgenogram, which shows the upper articular processes in front of the lower, but also on the anteroposterior roentgenogram, which shows the lateral or rotatory deviation. (See Figures 22-A and 22-B.) In the upper lumbar region, where the axis of the interarticular joints is in the frontal plane, the forward displacement of the upper articular processes has occurred not by "jumping" the lower processes, as may be seen in cervical dislocations, but by simply sliding forward. It is the secondary lateral or rotatory deviation which locks the processes. If in this region the anteroposterior view shows that the two upper processes still lie exactly between the two lower processes without any lateral or rotatory shift, reduction will probably succeed even though the lateral view shows the upper processes in front of the lower. A cautious attempt at reduction should be made, and check-up roentgenograms should be taken as the spine is gradually extended.

In the lower lumbar region the axis of the interarticular joints is not wholly in the frontal plane; indeed, it may be entirely in the lateral plane. In this region true jumping of the processes over each other occurs. Operative treatment is then essential, and it may be necessary to remove the articular processes of the lower vertebra on both sides.

SUMMARY

1. *Types of vertebral-body fractures.* This series of 252 fractures are classified in three groups,—simple wedge fracture, comminuted fracture, and fracture-dislocation. The simple wedge fracture is the most common and is due to a fall from a height, landing on the heels or the buttocks. It is often multiple; the intervertebral discs are uninjured; and spontaneous ankylosis is rare. The comminuted fracture is the most rare and is caused by forcible acute angulation. The intervertebral discs are ruptured, and bony ankylosis is common. Fracture-dislocation is due to the fall of a weight on the shoulders, and the spinal cord is usually injured.

2. *Methods of reduction.* The spine must be hyperextended to the normal limit. The position varies considerably in different patients; therefore, fixed or controlled degrees of extension by slings or curved surfaces are imperfect. The trunk should be entirely unsupported, so that it sags into space to the limit of the patient's extension movement.

3. *Results of treatment.* In the wedge and comminuted types of

fractures, excellent anatomical results are possible by the postural method. Two-thirds of the patients reported that their spines were as good as before they were injured; 80 per cent. resumed their original occupations. The average period of incapacity for those engaged in heavy labor was ten months; for those engaged in light labor, seven months. In fracture-dislocations, immobilization in extension is advisable; laminectomy is not advisable. The prognosis is bad in high thoracic dislocations with paraplegia, fair in cervical injuries, and good in lumbar injuries.

4. *Common sources of failure.* Uncorrected wedging causes persistent pain, due to interarticular-joint strain. Neglect of minor details of the technique of postural reduction causes failure. The jacket must not be cut below the clavicles or above the groins. The cutting of an abdominal window is not advisable. Early ambulation is quite safe. The jacket must be renewed after a few weeks. The patient should be immobilized for from four to six months. Posterior spinal supports are inadvisable.

5. *Hyperextension fractures.* These fractures are very rare. In the two cases described, one was a fracture of the vertebral body and the other was a fracture of the pedicles.

6. *Fracture-dislocation with locking of the articular processes.* In lumbar fracture-dislocation with bilateral dislocation of the interarticular joint, lateral shifting of the spine may lock the articular processes. If the spine is hyperextended, reduction fails and cord injury may be increased by stretching. One and rarely both of the lower articular processes must first be excised.

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THE HEALING OF FRACTURES OF ATROPHIC BONES*†

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Atrophy of bone signifies local, regional, or generalized wasting of the osseous tissues. This may result from disuse following paralysis, from long immobilization, from faulty absorption or faulty utilization of calcium and phosphorus, or it may be produced by a deficiency of these elements in the diet. In the growing child atrophy of bone is characterized by a relative decrease in diameter and in length, as well as by a decrease in density resulting from osteoporosis. When the condition is produced in the adult, it is manifested only by the porosis and attendant thinning of the supporting cortex of the bone or bones involved, while the actual size of the bone is not affected. Atrophy, which may result from disuse, change in blood pH by feeding ammonium chloride or similar acid-producing compounds, parathormone injection, hypervitaminosis D, diets deficient in minerals or vitamins, or total starvation, is much more readily brought about in growing experimental animals or in children than in adults.

Many clinicians, as well as scientists who are primarily concerned with laboratory research, have attempted to determine the importance of calcium and phosphorus or of vitamin D in the diet in the healing of fractures. They have expressed conflicting opinions concerning the healing of fractures in atrophic or osteoporotic bone. Interpretations of laboratory studies have differed widely, and in many instances results reported by one group have directly contradicted the conclusions of other clinical and experimental observers.

Murray states that fractures in osteoporotic bones heal promptly. Westphal and Hagemann have presented series of twelve and four clinical cases, respectively, and agree with Murray. Westphal's clinical series includes fractures in extremities in which atrophy had resulted from tuberculosis of the hip and the attendant immobilization. Westphal agrees with other writers who have concluded that these fractures in atrophic bones heal rapidly. The exciting trauma, the displacement of the fragments, and the symptoms are minimal. Tumpeer and McNeally, on the other hand, cite two cases of fractured atrophic bones in poliomyelitis, and conclude that, while callus formation does occur, the union is definitely

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weak, and in each of their patients there were recurrent fractures at the same site.

Experiments have been conducted on the effects of an excess or a deficiency of calcium in the diet; the importance of the quantity of calcium and phosphorus salts in the blood; the importance of local calcium depots, of the periosteum, and of vitamin D in the healing of fractures. Observers who have conducted quite similar experiments have often reported conflicting results. Downs concluded that an organic form of calcium phosphate in the diet produced better healing of fractures of the tibia than did an inorganic salt of calcium. Robb fed varying amounts of calcium and phosphorus to rats without any definite effect upon the healing of fractures, and Speed completed similar experiments in dogs, with the same conclusions. On the other hand, Berkheiser studied clinically the results of the feeding of mineral salts and completed one experiment with what he thought were beneficial results. However, a careful analysis of his case reports and a study of the roentgenograms of the healing fractures of the rabbit used in his experiment leaves room for considerable doubt in the mind of the reader.

An excellent review of the subject of the effect of the addition of calcium and phosphorus and of vitamin D to the diet upon fracture healing in the experimental animal may be found in an article by Fischer and Key. These authors reported that the addition of vitamin D and of calcium to the stock diet of the experimental animal would not lessen atrophy of disuse or accelerate the rate of union of bones. Significant was the finding of Roegholt that an insufficient amount of vitamin D caused delayed union, but he made no observations on the effect of an excess of vitamin D in the diet.

Downs and McKeown have shown that low-calcium diets may prolong healing and produce weaker union in fractured bones. Vitamin D in therapeutic doses has been reported by Grauer to help union, while overdoses have retarded repair. Swart, on the other hand, found that vitamin D did not influence fracture healing in any respect.

The importance of a rich local calcium depot, which can only be found in well-ossified bones, has been acclaimed by some to be the most important single factor bringing about fracture healing, while others [12, 16, 20] consider the question of local calcium depots to be without significant importance. Kernwein recently demonstrated that fractures in starving rabbits form fibrous callus and beginning bone trabeculae, but later the healing process halts and absorption of bone begins. In the animals that lived for thirty days or more, the bones of the skeleton became extremely osteoporotic and the initial callus itself underwent absorption.

In our own laboratory, experiments [5] have been completed which definitely showed delayed union, poor union, or non-union of fractures in animals with active rickets. Union occurred promptly in rachitic rats when vitamin D was added to the diet, but fractures of the long bones of rats fed a normal diet did not obtain more rapid union, or better union,

when excess amounts of vitamin D were added to the normal control diets. Urist, working independently, also found that active rickets delayed fracture healing.

The question of the influence of bone demineralization upon fracture healing seemed sufficiently unsettled to warrant further investigation. We were impressed by the bone atrophy and retardation of fracture healing which occurred in the rabbits which were starved in the experimental work of Kernwein. Fibrous union occurred in these fractures, but subsequently, and attendant upon the development of generalized osteoporosis, there was absorption of the lime salts from the callus. To us the hypothesis that a balanced ratio between the intake and the output of calcium and phosphorus, of vitamin D, and of the other elements of nutrition found in the stock diet is necessary for satisfactory healing of fractures seemed to be based upon reasonable presumptive evidence. The question of the relative amounts of these substances in the ideal diet for bone repair remained unsettled.

In the animals with active rickets, when vitamin D was added to the diet, healing of fractures was attended by rapid healing of the metaphyseal regions, with an increase in the diameter of the shafts, in the thickness of the cortices, and in the size of the trabeculae of the bones. It seemed advisable to try to settle the question of whether or not the delay in union in untreated animals showing active rickets resulted from the deficiency in the amount of bone fractured (osteoporosis) or in the specific pathology of rickets, of which the porosis was only a part.

CLINICAL STUDIES

An attempt was made to determine whether or not the fractures of atrophic bones of patients treated at the University of Chicago Clinics had united at the same rate and to the same extent as had fractures of normal bones of patients of similar ages. Atrophy was either regional, involving only the extremity in which the fracture had occurred, or a generalized osteoporosis. In the series studied, there were ten cases of fracture and seventy-seven cases of osteotomy of atrophic long bones. We found that it was impossible to compare accurately the rate or degree of healing as shown in the roentgenograms of these patients. The size of the callus has long been known to depend principally upon the degree of periosteal tear and the size of the hematoma formed at the site of the fracture, and is not a satisfactory indication of the degree and the rate of fracture healing. We attempted to study the length of time required for actual bony union to occur, as evidenced by trabeculae which crossed the line of fracture. This is the method of determining union which has been recommended by Häbler and Reiss. However, after reviewing all cases of fractures of atrophic bones, we found that too many variables were present to make possible a satisfactory scientific comparison or analysis. (See Figures 1 and 2.) The following difficulties in interpreting the degree of fracture healing in cases such as these can be enumerated:

1. The variation in the ages of the patients;
2. Irregular intervals between roentgenographic check-ups;
3. The difference in location of the break or osteotomy;
4. The difference in time or intensity of the roentgen-ray exposure;
5. The difficulty in interpreting the degree of union from a roentgenogram;
6. Variations in the individual character or quality of the bone in the different patients.

Although our observations could not be made with scientific accuracy, the impression gained from this study was that union occurred as readily in fractures of atrophic bones as in fractures of bones of normal density. The osteotomies also healed promptly.

As had been shown by Fischer and Key, arthrodesing operations upon the feet of patients who had had infantile paralysis, and whose bones in

FIG. 1

FIG. 1

These roentgenograms illustrate the difficulties encountered in attempting to compare the rates or degrees of healing in clinical fractures.

A: Fracture of the midshaft of the femur in a patient aged five years, two months after injury. The fracture is oblique, and there is evidence of bony union. An area of decreased density persists in the line of fracture.

B: Fracture of the femur at approximately the same level as in *A*. This patient is seven years of age, but the bones are atrophic as a result of long immobilization following reduction of a congenitally dislocated hip. Union occurred six weeks after fracture. There is some difference in roentgenographic technique and, while less callus is present, it is impossible to make any accurate comparison between the rate of healing of this fracture and that of the patient in *A*.

C: Extensive callus two months after fracture in a patient aged four years. In this instance the fracture is transverse, and there is displacement with some overriding.

It would not be possible to state with any degree of certainty that the rate of healing was any better in one of these cases than in another. The dates between the fracture and the check-up roentgenogram vary, and neither the types of the fractures nor the roentgenographic techniques are identical.

the extremity subjected to the surgical procedure were extremely atrophic, uniformly resulted in osseous union.

FIG. 2

Fracture of the humerus in three patients, all aged seven years.

A: Supposedly normal bone, seventeen days after injury.

B: Atrophic bone, four months after fracture, showing non-union. However, a study of interval roentgenograms showed that there had been definite callus and primary union with refracture.

C: Complete bony union two months after injury.

No two of these fractures are alike. The atrophic bone in *B* resulted from total paralysis of the arm. Further analysis showed that what appeared to be delayed union was in reality refracture, the primary union not being any stronger than the relative strength of the bone that had been fractured.

EXPERIMENTAL STUDIES

In our experiments, instead of attempting to produce regional atrophy by paralysis or immobilization, as had been done by other workers, we attempted to bring about generalized wasting of bones both in adult and in young growing rats by markedly reducing the intake of calcium. We then compared the rate and degree of fracture healing in these animals with others on a normal stock diet or on a diet with excessive amounts of cod-liver oil, calcium, or both of these supplements.

Experiment I—Healing of Fractures of Tibiae of Growing Rats

Procedure

White rats of the same stock, twenty-one days old, were used and kept on a diet for three weeks. Group A, consisting of sixteen rats, was placed on a low-calcium intake (300 milligrams of phosphorus and from forty to fifty milligrams of calcium per 100 grams of ration):

Ground whole yellow corn	33 per cent.
Ground wheat	33 per cent.
Wheat gluten	16 per cent.
Gelatin	16 per cent.
Cod-liver oil	2 per cent.

This is a modification of McCollum's diet [19] with cod-liver oil added and calcium left out. Group B included twenty-seven rats which were placed on a stock diet (modification from Bills and Honeywell [3]):

Ground whole yellow corn	52 per cent.
Whole-milk powder	26 per cent.
Linseed-oil meal	12 per cent.
Crude casein	4 per cent.
Alfalfa-leaf meal	1.5 per cent.
Brewer's yeast	1.5 per cent.
Sodium chloride	0.5 per cent.
Calcium carbonate	0.5 per cent.
Cod-liver oil	2 per cent.

After this period the right tibia of each rat was fractured manually. No splint was applied.

The rats were then divided into sub-groups as follows:

Group A—Fed on low-calcium diet for three weeks before fracture.

After fracture:

(1) 6 remained on a low-calcium diet.
(2) 5 changed to stock diet.
(3) 5 changed to stock diet plus 12 per cent. calcium and 8 per cent. cod-liver oil.

Group B—Fed on stock diet before fracture.

After fracture:

(1) 5 changed to low-calcium diet.
(2) 6 remained on stock diet.
(3) 6 remained on stock diet with added 8 per cent. cod-liver oil.
(4) 6 remained on stock diet with 12 per cent. calcium.
(5) 4 remained on stock diet with added 8 per cent. cod-liver oil and 12 per cent. calcium.

Roentgenograms were taken at the time of fracture and each week thereafter. One-half of the animals were sacrificed twenty-one days and the remaining rats twenty-eight days after fracture. The bones of the hind legs were removed, x-rayed, fixed, imbedded in celloidin, and sectioned.

Results of Experiment I

The rats on all diets gained weight and grew equally well, and in no

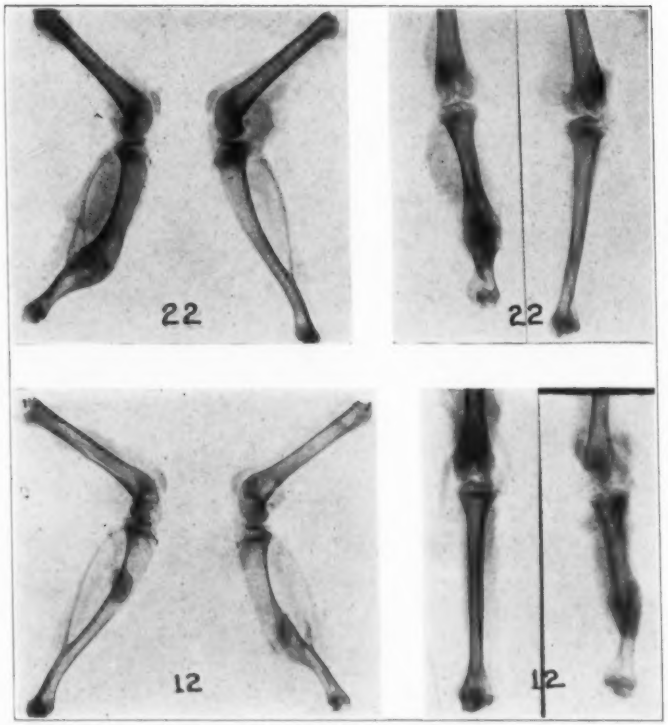

FIG. 3

Rat 22: Group A (2)—low-calcium diet for three weeks before fracture and normal stock diet for four weeks after fracture.

Rat 12: Group A (1)—low-calcium diet for three weeks before and four weeks after fracture.

The cortices of the femora, as well as of the tibiae, of Rat 12 are thinner than those of Rat 22, but there is no demonstrable difference in the healing of the fractures.

FIG. 4

Rat 12: Group A (1)—low-calcium diet for three weeks before and four weeks after fracture. There is thinning of the cortices of all of the bones shown. This is more marked in the extremity in which the fracture was produced than in the normal leg of the same animal.

Rat 32: Group A (3)—low-calcium diet for three weeks before fracture and stock diet with massive doses of calcium and cod-liver oil for four weeks after fracture.

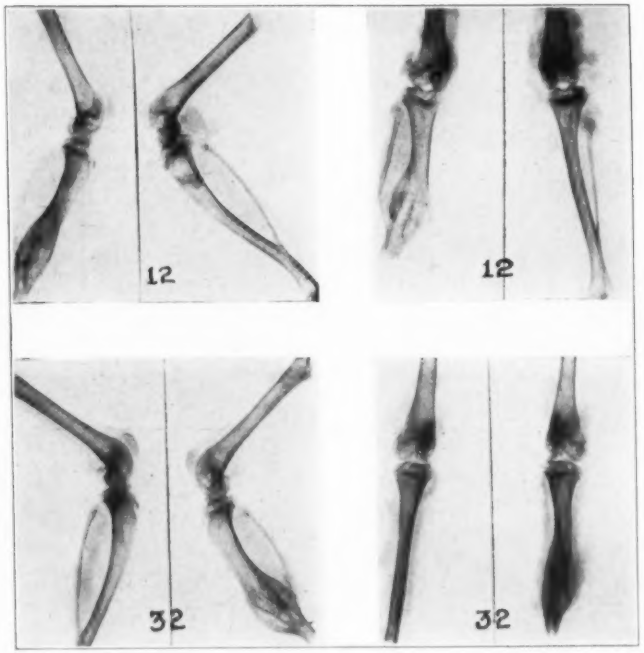

FIG. 4

There is very little difference between the bones of Rat 32 and those of Rat 12 which was on a calcium-deficient diet throughout the experiment. The fractures healed at about the same rate and to about the same extent. The roentgenograms were taken on the same film and printed on the same positive at the same time, so that the apparent demineralization in the bones of Rat 32 cannot be attributed to any difference in roentgenographic technique.

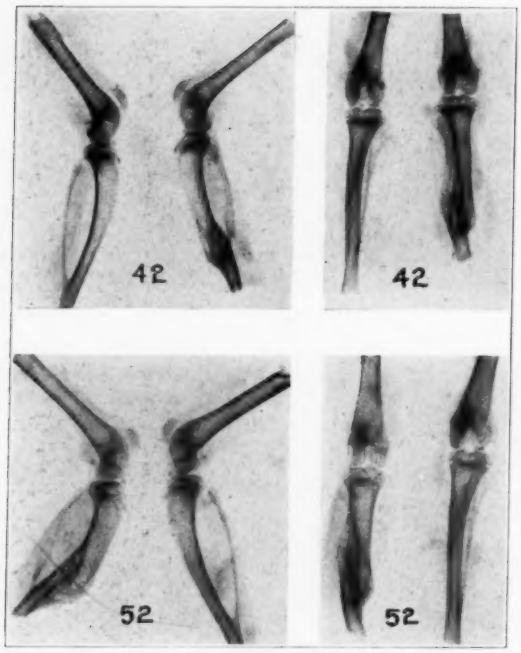

FIG. 5

Rat 42: Group B (1)—normal stock diet for three weeks before fracture and calcium-deficient diet for four weeks after fracture.

Rat 52: Group B (2)—normal stock diet three weeks before and four weeks after fracture.

The diameters of the bones of Rat 42 are less than those of Rat 52, and the cortices are thinner. There is about the same degree of displacement of the fracture fragments, and, while the total size of the ossified callus of Rat 52 is larger than that of Rat 42, the quality or degree of union of the fractures in the two rats is quite similar. The roentgenograms were made on the same film, at the same exposure, and were printed on the same positive, so that a comparison between the two is justified.

instance did rickets develop. All began to use their fractured legs for walking between the second and third weeks. Roentgenograms showed a moderate but definite bone atrophy, evidenced by relative thinning of the bone cortex and decrease in diameter of the shaft of the bones of animals on the low-calcium diet, Group A (1), as compared with the controls, Group B (2). Although attempts were made to keep the roentgenographic technique identical throughout the experiment, we were unable to form any definite opinions regarding relative degrees of healing from roentgenograms of the living animals. A few of the roentgenograms taken seven days after fracture showed faint callus shadows. On the fourteenth day, callus was demonstrated for all of the fractures, but a wide clear zone extended transversely across the callus between the bone ends. On the twenty-first day the callus was uniformly larger and more dense. However, the size of the callus seemed to conform more to the amount of angulation and overriding than to the amount of calcium or cod-liver oil in the diet. The uncalcified clear zone, which ran somewhat transversely across the callus and subsequently in microscopic sections was shown to be a zone of fibrous or osteoid tissue, was now much thinner. On the twenty-eighth day, in only a few of the specimens x-rayed could these transverse clear zones in the callus be seen. Most of the callus now showed bony trabeculae joining the fragments, but the medullary canals had not been reestablished. Roentgenograms of the cleaned long bones of the rats of Groups A (3), B (1), and B (4), taken on the same film at the same time and printed upon the same positive as bones from other groups, showed relatively thinner cortices and smaller diameters. (See Figures 3, 4, 5, 6, and 7.)

As estimated from studies of the roentgenograms, the rate of union was approximately the same in all groups, but the quality of union and of the bones themselves was best in the groups receiving normal stock diets throughout the experiment, and this was not definitely altered by the supplement of cod-liver oil or of a combination of calcium and cod-liver oil.

The rats receiving an excess of calcium added to the normal stock diet, Group B (4), or an excess of cod-liver oil and calcium added at the time of fracture to the previous low-calcium diet, Group A (3), showed in the roentgenograms of the specimens four weeks after fracture approximately the same relative degree of loss of bone density and at least no better quality of fracture healing than was present in the group that was constantly on the low-calcium diet, Group A (1), or that changed to this diet at the time of fracture, Group B (1).

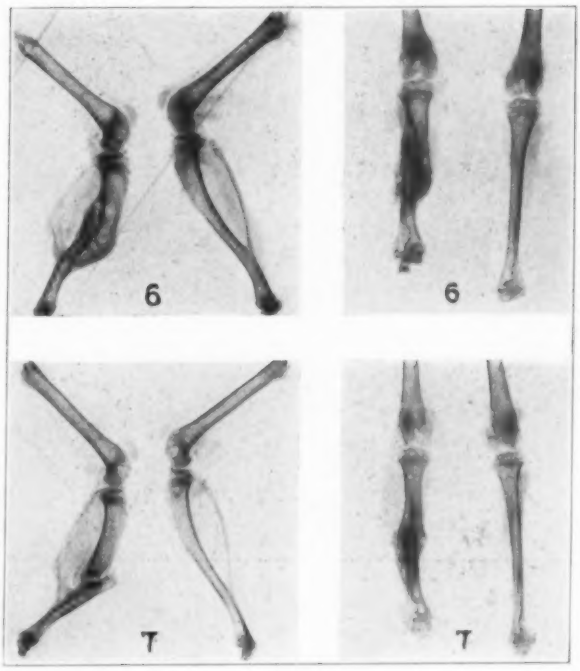

FIG. 6

Rat 6: Group B (3)—normal stock diet before fracture and high cod-liver-oil supplement for three weeks after fracture.

Rat 7: Group B (4)—normal stock diet before fracture and high-calcium supplement for three weeks after fracture.

There is no definite atrophy or difference between the bones of the rats in these two groups. The cortices of the femur and the tibia of the fractured extremity of the rat receiving the high-calcium diet (Rat 7) are not as well developed as those of the rat receiving the high cod-liver-oil supplement (Rat 6), but the difference is slight. There is approximately the same degree of displacement between the fracture fragments. Union of the fractures in the group receiving the cod-liver-oil supplement was better than that for the group receiving the excess amount of calcium. Roentgenograms of Rat 7, Group B (4), showed a continued zone of decreased density across the callus.

In *all* specimens, at the end of twenty-one days, microscopic sections showed ossification of the outer thirds of the external callus with some penetration of the bone marrow into and around the peripheral trabeculae. A new bony cortex was beginning to consolidate, but transversely between the ends of the fragments there was a fairly heavy strand of fibrous tissue which merged on either side with cartilage cells of the callus.

Microscopic sections of the specimens from the twenty-eight-day series showed greater differences in the degree of bone union at the sites

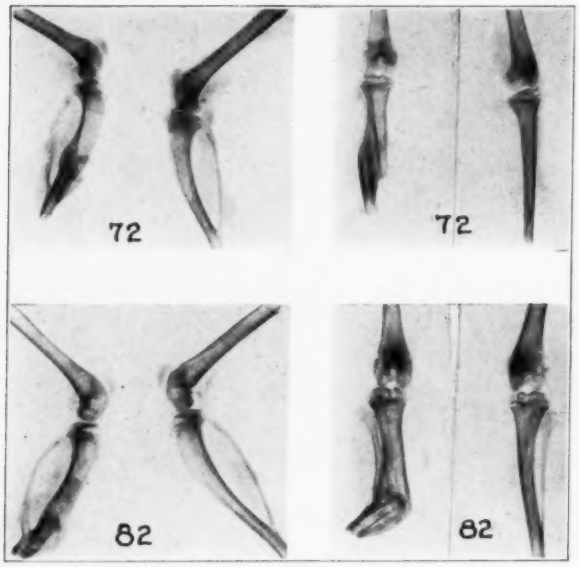

FIG. 7

FIG. 7

Rat 72: Group B (4)—normal stock diet before fracture and excess calcium as a supplement for four weeks after fracture.

Rat 82: Group B (5)—normal stock diet before fracture and high-calcium and high cod-liver-oil supplement for four weeks after fracture.

Comparison of the roentgenograms of the two rats shows a relative decrease in density of the bones of the rat receiving the high-calcium supplement (Rat 72), with less complete bony union of the fractures. The rat receiving supplements of both cod-liver oil and calcium (Rat 82) developed bones quite comparable to those of the normal control Rat 52 (Fig. 5).

of the fractures. (See Figures 8-A through 9-B.) In each specimen there was a well-formed new bone cortex, and the old cortex, which extended into the callus, was undergoing absorption. New bone trabeculae, many of them large and dense,

FIG. 8-A

Photomicrograph (×87) of a rat from Group A (3)—calcium-deficient diet before fracture and stock diet with high cod-liver-oil and high-calcium supplement for four weeks after fracture. A section taken through the callus at the exact level of the fracture shows bone trabeculae which are widely spaced, with a zone of dense fibrous tissue which represents the transverse shadow of decreased density in the roentgenogram previously described. The degree of ossification, as illustrated in this photomicrograph, is less than that in the rats of other groups, although this rat received a maximum of the supplement in the form of massive doses of calcium and cod-liver oil after fracture.

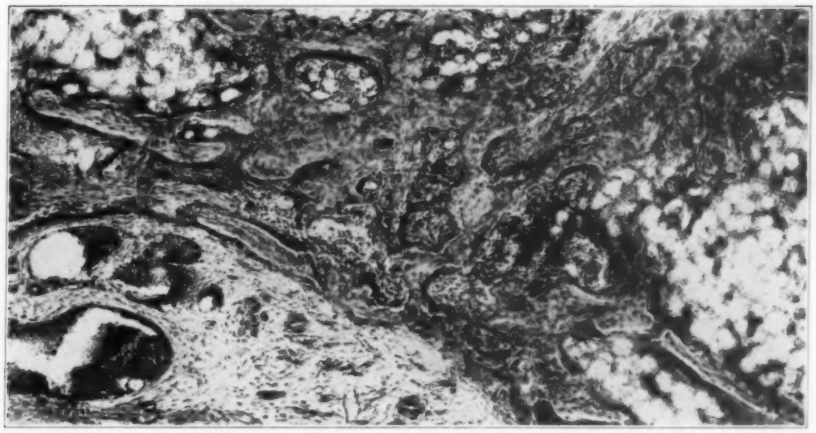

FIG. 8-B

Photomicrograph (×87) of a rat from Group A (1)—calcium-deficient diet for three weeks before fracture and for four weeks after fracture. Atrophic bone trabeculae extend completely across the site of the fracture. The trabeculae are widely spaced, with large areas of fatty marrow and fibrous callus in which are spaces filled with blood.

FIG. 8-C

Photomicrograph (×87) of a rat from Group B (2)—normal stock diet throughout. The animal was sacrificed four weeks after fracture. The degree of healing is definitely more advanced than in either Fig. 8-A or Fig. 8-B. The trabeculae of new bone are thicker. The marrow-filled spaces are smaller, and there is relatively little fibrous callus still present.

infiltrated the periosteal and endosteal callus. In a few instances the marrow cavities of the two fragments seemed to be continuous, but in most of them there were intervening trabeculae, and in many sections either a small band of fibrous tissue broke the continuity of the periosteal new bone or extended transversely across the mid-portion of the callus, or islands of cartilage were present and extended transversely in the endosteal callus. A detailed comparative analysis of the changes noted in the typical microscopic sections accompanies Figures 8-A through 9-B.

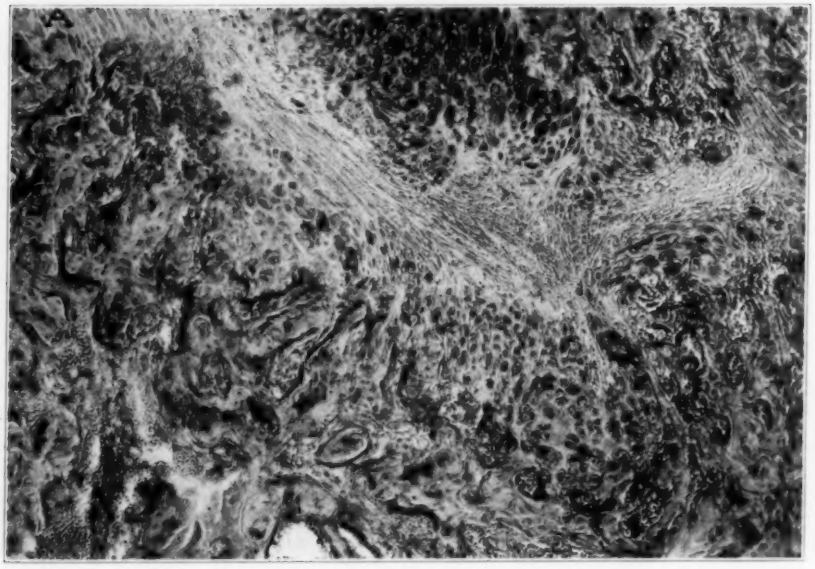

FIG. 9-A

Photomicrograph (×87) of a rat from Group B (4)—normal stock diet before fracture and excess calcium added to diet for four weeks after fracture. There is extensive replacement of the fibrous callus with thick bone trabeculae, but the zone of unossified fibrous tissue still extends completely across at the fracture site. On either side of this zone there is an area of unossified cartilaginous callus. Although this rat was not at any time on a deficient diet and received excess of calcium after fracture, the degree of healing, as evidenced both in the roentgenograms and in the photomicrograph sections, was less complete than in the rats receiving supplements of cod-liver oil, or calcium-deficient or normal stock diets without any supplement.

The quality of the union was comparable to the quality of the fractured bones.

Experiment II—Healing of Fractures in Adult Rats

Procedure

Twenty adult rats of average weight and size were divided into two groups of ten each. One group was fed the normal stock diet and the other was placed on the low-calcium ration used in Experiment I for four weeks. The right tibia of each of the rats was then fractured. The first group was allowed to remain on the stock diet. The low-calcium group was subdivided,—half remained on the same ration and the rest (five rats) were fed the low-calcium diet with added 3 per cent. ammonium nitrate for the purpose of increasing calcium excretion. Roentgenograms were taken three, ten, seventeen, twenty-four, thirty-one, and forty-five days after fracture. On each of the last three occasions, one-third of the animals in each group were sacrificed, and the fractured tibiae, together with the normal tibiae, were x-rayed on the same roentgenogram. Each fractured specimen was then fixed in celloidin and sectioned.

The low-calcium diet before fracture did not produce sufficient

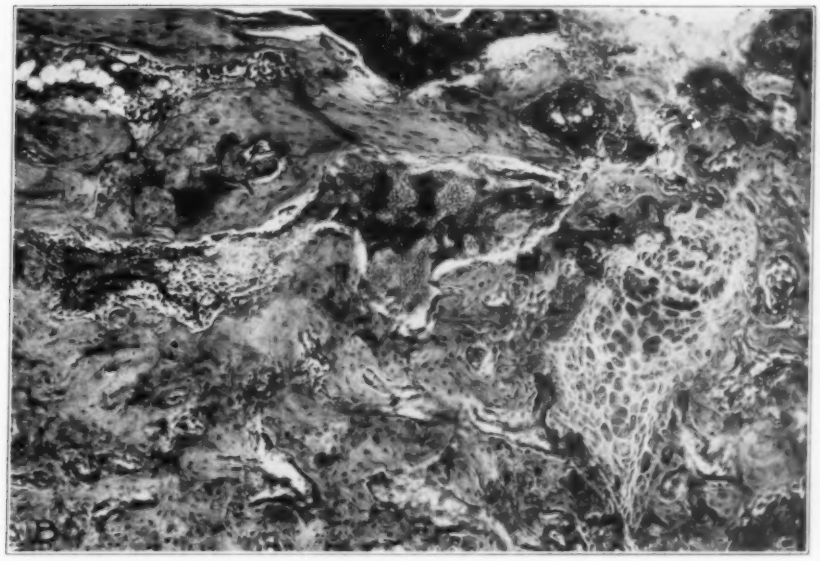

FIG. 9-B

Photomicrograph (×87) of a rat from Group B (3)—normal stock diet before fracture and high cod-liver oil supplement for four weeks after fracture. This photomicrograph shows more complete healing, as evidenced by larger bone trabeculae, fewer areas of fibrous or cartilaginous callus, and smaller areas of fat-filled marrow, as compared with the bones of the rat receiving the same diet plus calcium instead of cod-liver oil in the supplement (Fig. 9-A).

osteoporosis to be demonstrated in the roentgenograms. The addition of ammonium nitrate to the diet of one sub-group after fracture did not produce a condition of definite bone atrophy in the unfractured tibiae. Healing was shown, roentgenographically and microscopically, to progress well in all rats. A thin, transverse clear zone in the callus shadow was still present roentgenographically, and a corresponding zone of fibrous and osteoid tissue was demonstrated microscopically in each of the fractured tibiae obtained at necropsy forty-five days after fracture.

The adult rats were much less susceptible to a decreased calcium intake as far as bone density and fracture healing were concerned than were the growing animals. The addition of an acidifying agent in moderate amounts did not produce demonstrable bone atrophy or influence fracture healing in this experiment.

DISCUSSION

We were able to confirm the observation of Clarke, Bassin, and Smith that it is possible to produce atrophy of the bones of young growing rats by feeding a diet which is deficient in calcium, without the development of rickets. The changes in the skeleton caused by diets deficient in minerals are quite similar (although generalized) to the local atrophy of bone resulting from disuse, produced experimentally by Allison and Brooks.

Lachmann and Whelan have shown that before atrophy can be

demonstrated by the roentgenogram, in the neighborhood of 20 per cent. of the mineral element of the bone must be lost. Therefore, the roentgenogram is not a satisfactory method of determining slight changes in the mineral content of the bone. We were not successful in producing enough atrophy in the bones of adult rats in the time allowed for the experiment to enable us to make any definite statement from the roentgenographic comparisons. Jaffe, Bodansky, and Chandler reported that ammonium chloride added to a low-calcium diet produced marked osteoporosis and a picture quite similar to osteitis fibrosa if the decalcification was rapid. They further stated that calcium intake did modify the effect of ammonium chloride on the bone. In our experiments the addition of ammonium nitrate to the low-calcium diet of adult rats failed to produce demonstrable atrophy. All fractures in adult rats in all of the groups appeared to heal equally well. Definite roentgenographic, as well as microscopic, evidence of bone atrophy was obtained in the growing rats fed on a low-mineral diet.

In the study [5] which we had previously made, it was shown that fractures of rachitic bone did not heal as rapidly or as well as fractures of normal bone in animals of the same series. Fractures of non-rachitic atrophic bone, both in clinical cases and in the experimental animal, united as rapidly as did fractures in the normal controls. From these observations we may conclude that mesodermal tissue cells proliferate as well in the repair of a thin bone matrix as in that of a bone matrix of normal density, and perhaps sometimes more easily in the former. The speed of healing of atrophic bone, then, is at least not decreased, but the total amount of callus is on the average less than in bone in which there are more normal supplies of mineral salts and hence the union, as reported by Lindsay, is only as strong relatively as the strength of the shaft of the bone which has been fractured. We found that fractures of bones in either young or old rats on mineral-deficient diets did not heal more promptly or more adequately when large amounts of vitamin D or of calcium, or of both substances, were added to the diets than did those in rats which had been on a normal basic diet previous to fracture; in some instances, these supplements seemed to retard bone repair. The only two rats in our series which showed delayed union were in this group. We observed also that atrophy of the *fractured bone*, both in the low-calcium group and in the group of rats on the stock diet, was consistently more marked than in the unfractured extremity of the same animals. This may be explained by the fact that for a period of about two weeks after fracture the limb was not used normally.

Grauer reported the observation that massive doses of vitamin D not only did not improve fracture healing, but they seemed to delay union. Jones and Robson, in carefully planned and executed experiments, were able to demonstrate that irradiated ergosterol in toxic doses produced marked degenerative changes in growing bones of rats. Microscopic studies of these bones showed that the atrophy resulted from the removal

of the organic, as well as of the inorganic, matrix. There was definite osteoplastic activity, and the bones were soft and fragile. When these rats were fed low-calcium diets, together with the high-ergosterol intake, the picture was approximately the same.

Our studies would seem to indicate that there is a *threshold of mineral and vitamin normalcy* below which bones become atrophic. If the vitamin-D deficiency is marked, rickets also develops and fractures of the rachitic bones heal very poorly. If the deficiency is largely of the mineral element, bones may become atrophic with no rachitic changes without affecting the rate of fracture healing, and the quality of union will be comparable to the quality of the bone fractured.

SUMMARY

1. Atrophy of bones of young rats was produced by feeding a diet low in calcium content.

2. The healing of fractures of atrophic bones produced by a diet low in calcium progressed to the stage of complete bony union at a rate comparable to that observed in animals of a control series fed a normal stock diet.

3. The total amount of bone laid down in repair was less and the new trabeculae and cortices of the bone were definitely thinner in those animals fed the deficient diet than in those constantly receiving a diet adequate in calcium.

4. Addition of an excess of vitamin D or calcium carbonate, or both of these elements, to the diet of rats, whether they had been previously on a diet low in calcium or on a normal stock diet, did not hasten the rate or improve the quality of healing of the fracture, as compared with the fracture healing of rats constantly fed the normal stock diet.

5. Some evidence is presented to indicate that massive doses of calcium or of calcium and vitamin D by mouth may produce an inhibiting effect on the quality of healing of fractures of normal or atrophic bones.

6. Since the vitamin-D requirement for the average human adult is not known, and since massive doses of vitamin D may produce atrophic changes in the bones of experimental animals and delayed healing of fractures, we question the advisability of continuing the practice now becoming common of prescribing massive doses of vitamin D, or of vitamin D and calcium, for patients with fractures, in whom there is no evidence of a deficiency of these elements.

7. There is a real need of a carefully planned and executed long-time study to determine the vitamin-D and calcium requirements of the average adult human.

CONCLUSIONS

A study of the importance of vitamin-D supplements in the healing of fractures either of atrophic or of normal bones was not the original or primary reason for undertaking the experimental work which we have de-

scribed. As we began to analyze our results it became obvious that they would support the conclusions of other laboratory workers who had reported degenerative changes in the bones following prolonged administration of large doses of vitamin D.

Within the past few years there has been a growing tendency on the part of clinicians to prescribe enormous doses of vitamin D in the form of purified concentrates. The dangers of hypervitaminosis D have been either unrecognized or ignored. Doses as high as 500,000 international units have been used and recommended in the treatment of arthritis, and the addition of supplements of vitamin D, or of calcium, or of both of these substances, to the well-balanced normal diet of patients who have sustained fractures of apparently normal bones has become common practice. Patients frequently demand to know why we do not recommend these supplements because their friends or acquaintances have taken them upon advice of their physicians.

Studies referred to in this paper indicate that lack of vitamin D to the extent of the production of rickets may be a factor in causing delayed union or non-union. There is *no good evidence* that the addition of vitamin D or of calcium to the average stock diet of experimental animals or to the well-balanced diet of patients has *any beneficial effect in the healing of fractures.* The results of experiments reported in this paper and those from other laboratories indicate that large doses of these supplements may cause delay in the healing of fractures and wasting of the bone substance, as demonstrated in roentgenograms and in photomicrographic sections. Recent observations in a few clinical cases have added to the evidence obtained in work with experimental animals that delayed healing of fractures in some patients may be the result of hypervitaminosis D and not, as is so commonly assumed, of a deficiency of this substance in the diet.

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AN ARTHROPLASTIC PROCEDURE FOR CONGENITAL DISLOCATION IN CHILDREN *

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Any operative procedure advocated for congenital dislocation of the hip must have proved its effectiveness over a period of years, and any evaluation should be based both upon the functional result and upon the postoperative changes noted roentgenographically.

Everyone interested in this problem recognizes that there is an age limit under which actual reduction and functional cure can be accomplished, and an age limit beyond which actual reduction is impossible or, if possible, fraught with so many dangers that it is not desirable.

Galloway [3] has long advocated open operations on very young children, but we feel that under the age of three closed reduction is still the method of choice. In a recent end-result study [5] of congenital dislocation of the hip in children under three, treated by closed reduction and manual correction of the anterior distortion, functional and anatomical cures were reported in 75 per cent. of the unilateral cases and in 65 per cent. of the bilateral cases. We think that this is a higher percentage than is usually obtained, and we attribute it to the recognition and correction of the anterior distortion by manual osteoclasis [4], feeling that open operation in children under three should be reserved only for those cases in which a closed reduction has failed. We believe that the procedure advocated is particularly applicable to the young patient in whom reduction cannot be maintained by the closed method.

We have tried to define an age limit for the procedure advocated, and would say that the best results have been obtained in children under the age of eight. We feel at this time that the upper limit for the procedure in the unilateral case should be ten, while in the bilateral case the best results are obtained in children under six or seven years of age.

Many procedures have been advocated to correct the increasing instability in growing children, but few open operations have achieved free mobility with a true reduction of the upward and backward dislocation of the head of the femur. The purpose of the arthroplastic type of acetabular reconstruction presented here is to obtain actual reduction of the dislocation, restoration of stability to the hip joint, and preservation of a satisfactory range of movement.

The congenital maldevelopment of the acetabulum is generally accepted as the underlying cause of the occurrence of the dislocation, but

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varying secondary changes that soon take place in the upper extremity of the femur and in the surrounding soft tissues all have to be reckoned with in considering these unstable and shortened limbs. There are two very important factors upon which the prognosis is largely based,—the age of the patient, which has already been mentioned; and the laxity of the tissues about the joint, evidenced by the telescoping manoeuver. Laxity of the soft tissues is a variable quantity, and, although not wholly dependent upon age, it is largely so. The degree of soft-tissue relaxation can be easily determined before beginning treatment by taking two roentgenograms, one with and the other without manual traction. The question of anterior distortion in the cases that have come to open operation, has not, in our hands, proved to be such a problem as in cases treated by closed methods of reduction, for in only a few instances have we found it necessary to do a supracondylar osteotomy. We feel that this is probably because we are able to reconstruct the acetabulum at the time of the second stage, and this allows the stability of the reduced head of the femur to depend, not upon the anatomical shape of the maldeveloped acetabulum, but upon the depth and slope of the reconstructed socket made at open operation.

The capsule-covered head of the femur is almost always displaced, not only upward, but backward, and, if the type of operation chosen does not succeed in bringing the head both downward and forward, the lordosis and characteristic limp will be improved very little. In addition to these changes, the abductor group of muscles, as well as the adductors, the hamstrings, and the rectus femoris portion of the quadriceps, are shortened and contracted, making a preliminary period of effective traction necessary before any open operation is advisable.

FIRST STAGE

We have found that, within the age limits mentioned, we can usually pull the femoral head down, so that it is approximately opposite the original site of the acetabulum. This has been done in a variety of ways. In the younger patient, it is necessary only to apply moleskin to the affected limb twenty-four hours previous to a thorough stretching and subcutaneous tenotomy. This permits the moleskin to be well attached to the skin before traction is instituted. In other cases, we have used skeletal traction on the lower end of the femur. In a few of the older patients, a curved incision has been made along the crest of the ilium and a subperiosteal stripping of the gluteal muscles has been done, which is particularly to be recommended in the older and more resistant cases.

Various methods have also been utilized to immobilize the pelvis and to obtain effective downward traction on the limb. The most satisfactory method in our hands has been the application of a well-padded long plaster spica to the opposite side and traction of from fifteen to twenty-five pounds over a period of time sufficient to relax the contracted tissues thoroughly and to bring the head of the femur opposite the site of the original

acetabulum. This first stage in the procedure may require two or three weeks, or even longer, but it is very important to delay the second stage until the maximum relaxation has been obtained and the position of the head proved by roentgenograms.

SECOND STAGE

In some instances, the Smith-Petersen approach has been used, but the following procedure has been more frequently employed. A skin incision is made, beginning about two inches behind the anterior superior spine, curving forward, downward, and then backward to a point on the thigh about two inches below the tip of the greater trochanter. The origin of the rectus femoris tendon at the anterior inferior spine is identified and examined. If it seems contracted, it is divided by a zigzag tenotomy. The fascia on the lateral aspect of the thigh is then cut transversely, and a portion of the tip of the greater trochanter with the attached gluteal muscles is identified, chiseled through, and turned upward. The elongated portion of the capsule of the hip joint covering the head of the femur is easily identified and completely separated from the surrounding structures by careful dissection with scissors. When the isthmus of the capsule is reached, it is divided; the head of the bone is inspected, and the shape and the presence or absence of the ligamentum teres are noted. Many of the cases have shown the acorn-shaped type of head, with smooth, glistening normal-appearing cartilage and not a trace of the ligamentum teres; in some instances only a short, flat, ribbonlike structure remained. In the younger patient there has often been noted an elongated and well-developed ligamentum teres, and a division of this structure has apparently caused no later disturbance in the development of the head of the femur. After the appearance of the femoral head has been noted, the opening in the capsule is closed with several chromic sutures. With Doyen reamers, or preferably with a large curette, a capacious acetabulum is formed as near its original site as preliminary traction has made possible. The site of the acetabulum is further checked by identifying the triradiate cartilage in its floor. After this has been done, the capsule-covered head is gently pulled down and placed *without force* in the deepened and reamed-out acetabulum; the abductor muscles with the attached cartilage from the greater trochanter are sutured back into place. The wound is then closed in layers, and a long plaster spica is applied. This plaster is retained for four weeks, but two weeks after the second-stage operation the posterior portion of the cast covering the foot and leg is removed, and active movement of the knee is accomplished whenever the patient is lying on the abdomen. At the time when the patient is turned over, the posterior shell is strapped back into place and supports the leg and foot. Four weeks after operation, the entire plaster is removed, and the limb is suspended in a posterior splint. At this time, active and passive motions are started and the patient is encouraged to use the abductor, the flexor, and the extensor muscles during a portion of each day. No weight-bearing is

advised for three months after operation; if desired, the patient can then be fitted with a Thomas walking splint, although this has rarely been done.

This method was originally described in 1932 [1] and has been employed practically unchanged ever since.

DISCUSSION

The following statement from a previous article [2] on this subject, published in 1936, is still applicable: "While the time of follow-up with the procedure advocated is insufficient to draw any definite conclusions as to what will be the ultimate functional and roentgenographic appearance of these hips, certain observations have been noted in the patients operated upon. The hips have all remained reduced and stable with a varying degree of movement. . . . By cutting through the greater trochanter a stimulation of its growth has been observed, and this in the later cases appears to have been lessened by carefully removing only a small portion of the cartilage when the abductor muscles are reflected upward during the second stage. A surgical fusion of this epiphysis at this stage might obviate this, but it has not been considered necessary to date. An increased density of the roof of the reamed-out acetabulum has been a frequent finding and we must assume that the transplanted capsule about the head becomes attached to the newly formed acetabulum, allowing the head to move easily within it. The depth of the reamed-out acetabulum appeared either unchanged or in some instances even appeared to have become deepened after several years of weight bearing."

The complications met with in this operation depend upon two general factors. The first is failure to recognize the age limit of the operation. The fact seems to be true that in the adolescent child the structures about the dislocated hip are unable to lend themselves to the accommodative changes necessary to produce a satisfactory range of movement. The loss of mobility in the unilateral reconstructed hip is not a particularly serious complication, but we feel that it should be avoided if possible, and in this older age group we prefer some type of osteoplastic buttress. The second factor determining a satisfactory functional hip is dependent upon the degree of trauma produced in reducing the head into the reconstructed acetabulum. If the stretching of the tissues in the first stage has not been effectively accomplished, the capsule-covered head cannot be easily and gently placed into its new site, at the second stage. Vigorous manipulation or replacement of the head under tension, as with the aid of a skid, will give an opportunity for pressure necrosis, not only of the capsule over the head, but even of the head itself.

We have had no deaths following the procedure, and, since doing the first operation in 1930, we have attempted, by the trial and error method, to determine the limitations of the procedure.

Only a long period of time can conclusively prove the value of any method for treating congenital dislocation of the hip, but we now feel that within the age limits mentioned, and following the method outlined,

one will obtain a most satisfactory result functionally and roentgenographically.

The method is, therefore, presented for consideration; its limitations are stressed; and it is hoped that it may be tried by other orthopaedic surgeons and properly evaluated.

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RECURRENT DEFORMITIES IN STABILIZED PARALYTIC FEET

A Report of 1100 Consecutive Stabilizations in Poliomyelitis

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Stabilization of feet totally or partially paralyzed has long been recognized as a valuable adjunct to the therapeutic measures available for patients with residual poliomyelitis. The type of stabilization has varied from simple arthrodesis of the talocalcanean joint to the more extensive procedures in which several joints of the foot are fused. Stabilization alone was originally thought to be sufficient to ensure a permanent satisfactory weight-bearing foot, irrespective of the type of foot present, the deformities in the remainder of the extremity, or the status of the individual muscles about the foot and ankle. Subsequent findings, however, have proved that these other seemingly extraneous factors have to be considered if a permanent satisfactory result is to be obtained.

Since the St. Louis unit of the Shriners' Hospitals for Crippled Children was opened in 1924, 1100 feet have been arthrodesed for the correction of deformities associated with residual poliomyelitis alone. In the majority of these feet, the ordinary triple arthrodesis was used,—namely, arthrodesis of the talocalcanean, talonavicular, and calcaneocuboid joints. In some, the calcaneocuboid joint was not fused, and in a few of the earlier ones, only the talocalcanean joint was done. This entire group of feet were operated upon by or under the direct supervision of only eight men, all of whom were adequately trained. This ensured a well-controlled series and should serve to prove that inadequate operation was a negligible factor in the recurrence of deformities. In spite of this fact, 212 recurrent deformities have been encountered in this series of 1100 feet. This represents approximately 20 per cent. of recurrences, and is far higher than was expected at the time this study was begun. The evaluation of the end result in each case was made by personal observation of one or of both authors and not by a simple résumé of notes left by other individuals. One might at first assume, as we did, that most of the recurrences took place several years ago before the field of reconstructive surgery had been developed to its present-day status. However, we were surprised to find that one-third of these deformities had occurred during the last five years. In other words, these deformities are still occurring in spite of our attempts to give each patient a well-balanced foot and a correctly aligned extremity from a mechanical standpoint.

Many of these recurrent deformities have been mild, but *every variation from what should be considered a perfectly satisfactory end result has been included.* In our opinion, only seventy-four of these recurrences (7 per cent. of the total number of cases) were severe enough to justify additional surgical procedures. The deformity was corrected at a second operation in seventy cases and in the remaining four restabilization was advised but refused.

Follow-up examinations have been carried out in the majority of these cases over a period of several years. It has been found that approximately one year is required for a recurrent deformity to become well developed, and any case followed for a shorter period of time cannot be classed as a permanent satisfactory end result. In this series, there were ninety-seven feet in which no follow-up examination was possible, or the cases were followed for less than a year. These might have eventually presented evidence of recurrences. Had complete follow-up been possible in every case, our percentage of recurrences might be still higher.

An attempt has been made to analyze each case and to establish as nearly as possible the exact reasons for the recurrence. The etiological factors can be listed, and will be discussed as follows:

1. Abnormal muscle pull;
2. Associated deformities in remainder of extremity;
3. Patient too young when stabilization was done;
4. No demonstrable cause for recurrence.

One or more of these etiological factors may be present in the development of the recurrence. For instance, there were fifty feet showing not only an abnormal muscle pull, but also associated tibial torsion or knock-knee. Some form of abnormal muscle pull is obviously the most frequent and most important of the various factors, and recurrent deformities have only been attributed to factors other than this when it has been impossible to explain them on the basis of muscle imbalance.

ABNORMAL MUSCLE PULL

Stabilization of any foot abolishes the motion only in the intertarsal joints which are fused, leaving intact the motion in the remainder of the foot. In the usual triple arthrodesis, the hind foot is thus made stable, but a deformity is still possible in the fore foot unless the muscle power on the two sides of the ankle joint is in perfect balance. Arthrodesis of the ankle will not abolish this tendency, as the deformity takes place in the fore foot.

In our series, some form of abnormal muscle pull definitely accounted for 155, or 73 per cent. of the recurrent deformities. Strong peroneal muscles were responsible for eighty-eight of these. This recurrence is the result of normal or strong peroneals in opposition to weak or paralyzed anterior and posterior tibials. Some occurred in earlier cases where the peroneus longus tendon alone was transplanted forward into the dorsum of the foot to replace a paralyzed tibialis anterior. In these, the peroneus

brevis left behind was often strong enough to pull the fore foot out of line. In other feet, this type of deformity has occurred where the peroneals were left intact, as it was believed that they were adequately balanced by the power of the anterior and posterior tibials. This type of recurrence presents a very characteristic picture. (See Figure 1.) The stable hind foot remains in good position, with the heel in proper alignment with the ankle joint. The fore foot, however, is pulled into a valgus position and in addition is definitely everted. Both the peroneus longus and the peroneus brevis serve as factors in this valgus tendency, while the peroneus longus produces the eversion. This is made possible by its pulley effect in the groove on the inferior surface of the cuboid and its path across the plantar surface of the foot to insert into the first cuneiform and base of the first metatarsal. In the development of this deformity, the anterior and posterior tibials must be weaker than the peroneal group. In the normal, well-balanced foot, the tibialis anterior and the peroneus longus counterbalance each other in their actions. The tibialis anterior inserts on the dorsum of the longitudinal arch and tends to elevate it and to invert the foot, while the peroneus longus inserts on the plantar surface and tends to depress the arch and to evert the foot. Their directly opposite actions help to maintain satisfactory balance and correct architectural structure in the normal foot. Therefore, the loss of the lifting effect of the tibialis anterior on the inner border of the foot is an additional factor in the eversion deformity. Associated with this, the inner border of the foot is flatter than normal, although this is largely controlled by the stabilization. A few feet have been seen in which normal extensor muscles to the outer toes also aided in this deformity.

FIG. 1

A typical recurrent deformity resulting from an unopposed peroneal group left intact following the original stabilization.

A: The foot is in good position following the triple arthrodesis.

B: The same foot six years later. Note that the hind foot remains in correct relationship to the ankle joint, while the fore foot has been pulled laterally as a result of the abnormal pull.

C: The correct alignment has been restored after reconstruction of the fore foot and transplantation of the tendons of the peronei into the calcaneum.

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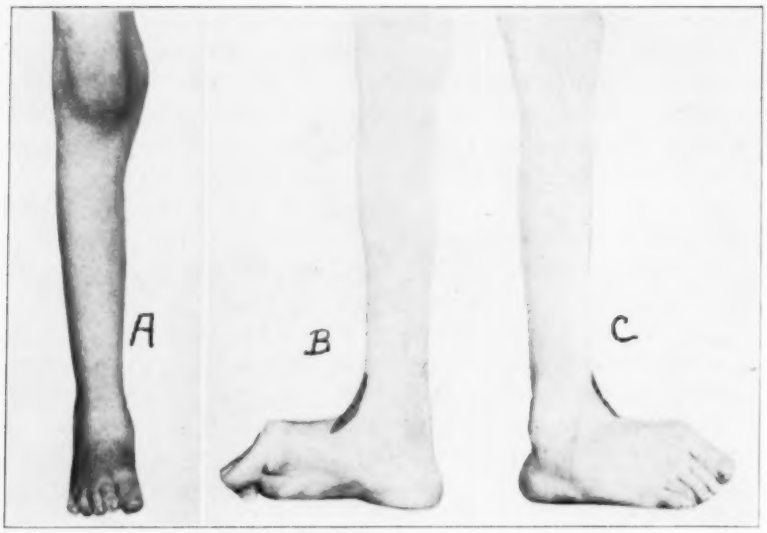

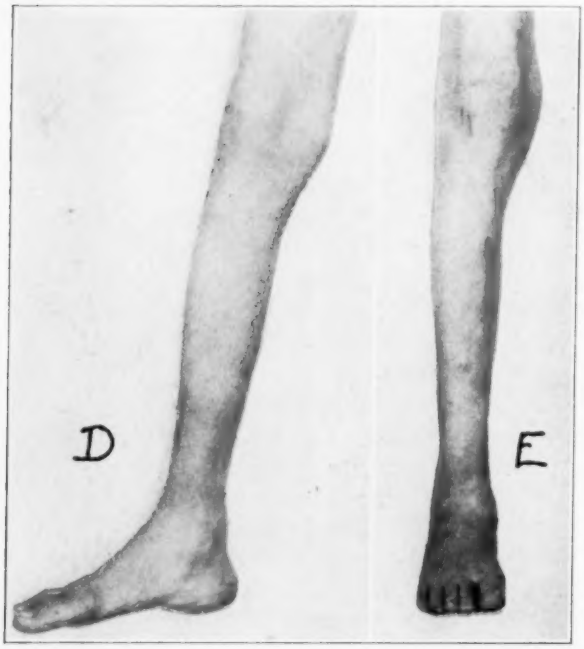

FIG. 2

A typical recurrent deformity, the result of an unopposed normal tibialis anterior.

A: Result following the original stabilization.

B and *C:* Medial and anterolateral views of the foot two years later. The heel remains in good position, but there is an inversion and adduction deformity of the fore foot.

D and *E:* Views of the same foot following reconstruction of the fore foot and transplantation of the tendon of the tibialis anterior to the mid-tarsus.

normal and unopposed tibialis anterior alone produced a recurrent deformity in thirty feet. The tibialis posterior was responsible for six recurrent deformities, while the combined pull of both served as etiological factors in twenty-seven feet. When the calf group of muscles is strong enough to prevent a true calcaneus deformity, the action of both tibial muscles produces an adduction of the fore foot, and the hind foot again remains in good position as a result of the stabilization. When the tibialis anterior is the primary etiological factor in the recurrence, however, the deformity is almost directly opposite that as described for the peroneal group. There

is then, in addition to the varus element, a definitely high inner border and an inversion of the fore foot. (See Figures 2, 3, and 4.) In such feet, the peroneals are always paralyzed or weak. The loss of the counterbalancing effect of the peroneus longus on the plantar surface of the longitudinal arch leaves the strong tibialis anterior unopposed in its action and facilitates the actual development of such a change in the bony structure. The tibialis anterior has been seen in some instances to produce a recurrent calcaneus deformity when it has been left intact after stabilization of a true calcaneus foot. In these, there is also seen this same inversion of the fore foot so characteristic of the action of this muscle.

A few other recurrent deformities have been encountered as a result of other abnormal muscle pulls. Some have occurred from the abnormally strong pull of peroneal tendons transplanted to the dorsum of the foot. If the tendons are transplanted so that they are not directly in the mid-line, the fore foot can be pulled to one side or the other depending on which side of the foot is favored in the insertion. It is unusual to see peroneal tendons that have been transplanted forward develop to this extent, but a few such cases have been encountered. The majority of these were among the earlier cases where an attempt was made to place the transplant into the navicular bone itself, supposedly near the insertion of the paralyzed tibialis anterior. Two cases have been seen with a valgus deformity of the fore foot as a result of strong outer-toe extensors with complete paralysis of the peroneal group. One recurrent calcaneus deformity resulted from the action of the toe extensors alone, and one fixed recurrent equinus deformity resulted from a group of unopposed

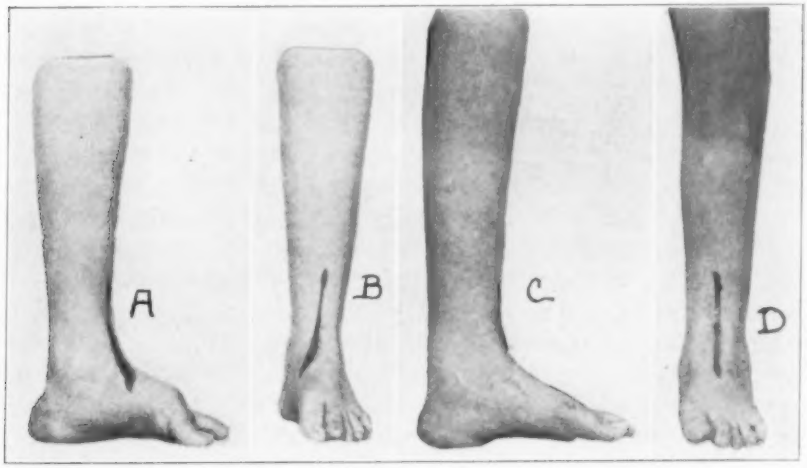

FIG. 3

A and *B:* Medial and anterior views of a recurrent deformity resulting from an unopposed strong tibialis anterior, three years after stabilization. Note that the heel is in good position, while the fore foot is inverted and its inner border is definitely elevated.

C and *D:* Similar views following reconstruction of the fore foot and transplantation of the tendon of the tibialis anterior to the mid-tarsus.

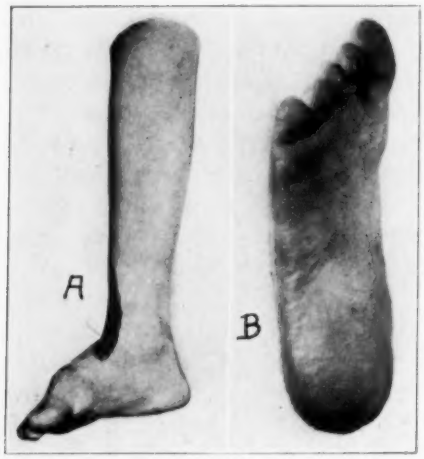

FIG. 4

A: Medial view of a recurrent deformity resulting from an unopposed tibialis anterior, one year after stabilization.

B: Plantar view of the same foot. Note the excellent position of the heel with the inversion of the fore foot.

C: Medial view following reconstruction of the fore foot and transplantation of the tendon of the tibialis anterior to the mid-tarsus.

normal calf muscles. Recurrent drop-foot has been controlled quite well by the type of stabilization employed in such instances, and, for that reason, fixed recurrent drop-foot deformities have been exceedingly rare. Weight-bearing itself is, of course, a major factor in the prevention of a fixed recurrent deformity of this type.

Many of these deformities have resulted from an attempt to estimate the equality of muscle power on the two sides of the ankle joint, transplanting only those tendons which were considered indicated in order to establish this equality. An example of this was the early practice of transplanting the peroneus longus tendon forward to replace a paralyzed tibialis anterior, leaving the peroneus brevis intact. In this way, much of the muscle power on the medial and lateral aspects of the ankle joint may be left undisturbed. Experience in this series of cases has proved that this is not a wise procedure, as recurrent deformities will almost invariably follow such a practice. One reason for this is that the power in individual muscles frequently changes after correction of a deformity by stabilization. A muscle may originally be very weak as a result of stretch in a marked foot deformity. Then, after correction of this deformity, much of its power may be regained, and, if left intact, may produce a deformity of the fore foot directly opposite that which originally affected the entire foot. Also, recurrent deformities have developed in many instances where muscles were left undisturbed, because it was thought that they were too weak to be of any significance.

After arthrodesis of a foot, there is no need for muscle power on the medial and lateral aspects of the ankle joint. Therefore, no muscle is now left intact on either side of the foot following stabilization, unless the muscle is known to be completely paralyzed. The only exception to this rule lies in the cavus deformity, secondary to a paralysis of the intrinsic muscles of the foot, where all the long muscles are normal in power and

there is no evidence of deviation from the mid-line. If the muscles are not needed as transplants, they can be removed by the excision of a segment of the tendon five or six inches in length. We have seen tendons regenerate sufficiently, following simple section or excision of segments one inch in length, to be practically normal in power and capable of producing secondary deformities. Transplantation is usually carried out, however, as this is almost as simple as excision, preserves function in the involved muscles, and thus prevents additional atrophy and change in the contour of the leg, which is especially important in girls. The tendons on the anterior and posterior aspects of the joint must then be placed as nearly in the mid-line as possible in order to keep the foot properly aligned.

From a functional standpoint in walking, the most important muscle group about the foot is the calf group, as it must lift the entire weight of the body with each step. There is needed only sufficient power on the anterior aspect of the ankle joint to lift the weight of the foot itself against gravity. If necessary, any drop-foot tendency of importance can be controlled by the type of stabilization employed. Therefore, the muscle transplants are almost always inserted into the calcaneum. These muscle transplants must be inserted into bone if permanent satisfactory function is to be expected. When transplanted into paralyzed tendons only, they will eventually stretch the paralyzed tendons to such an extent that the function is lost.

In a varus foot, the tibialis anterior, if present, is transplanted to the mid-tarsal region, an attempt being made to place it directly in the mid-line. The tendons of the tibialis posterior and the peronei, if they show any residual power, are then transplanted to the calcaneum if the calf group of muscles is not normal; otherwise they are excised. In a varus foot with a paralysis of the tibialis anterior and a functioning tibialis posterior, the tibialis anterior tendon is not transplanted. If fair power is still present in the peroneal group, these tendons are transplanted forward to the mid-tarsal region. In some cases, the tendon of the tibialis posterior has been transplanted forward to the mid-tarsal region, but in none of these has the tendon ever functioned, and the procedure is no longer used. If satisfactory toe extensors are present, they will furnish adequate power in flexion of the foot, and no additional power in front of the ankle is needed. The extensor hallucis longus tendon is then transplanted to the neck of the first metatarsal, and the interphalangeal joint of the great toe is arthrodesed. In this type of foot, the tendons of the peronei are shifted back to the calcaneum along with the tendon of the tibialis posterior.

In valgus feet resulting from strong peroneal muscles, there is usually sufficient power in the toe extensors to ensure adequate dorsiflexion of the foot. The tendons of the peronei are then transplanted into the calcaneum along with the tendon of the tibialis posterior. If all the toe extensors are completely paralyzed in such a foot, and adequate calf muscles are present, the tendons of the peronei are transplanted to the mid-tarsal region. If the calf group of muscles is weak, however, all

transplants are inserted into the calcaneum regardless of the status of the dorsiflexors of the foot. Here again, any drop-foot tendency can be controlled by properly shifting the foot at the time of stabilization. If any function remains in the tibialis anterior, the attachment of this muscle is shifted over to the mid-tarsal region.

In a calcaneus foot, the tendon of the tibialis anterior is passed through the interosseous membrane and transplanted into the calcaneum, together with the tendons of the tibialis posterior and the peronei, regardless of the power in the extensor tendons of the toes. If the toe extensors are still functioning, as is usually true in such a foot, the extensor hallucis longus is shifted back to the neck of the first metatarsal, and the interphalangeal joint of the great toe is fused. This prevents a cock-up of the great toe, assures a more normal looking foot, and prevents an abnormal point of weight-bearing beneath the head of the first metatarsal. Even when all the toe extensors are paralyzed, the tibialis anterior still is

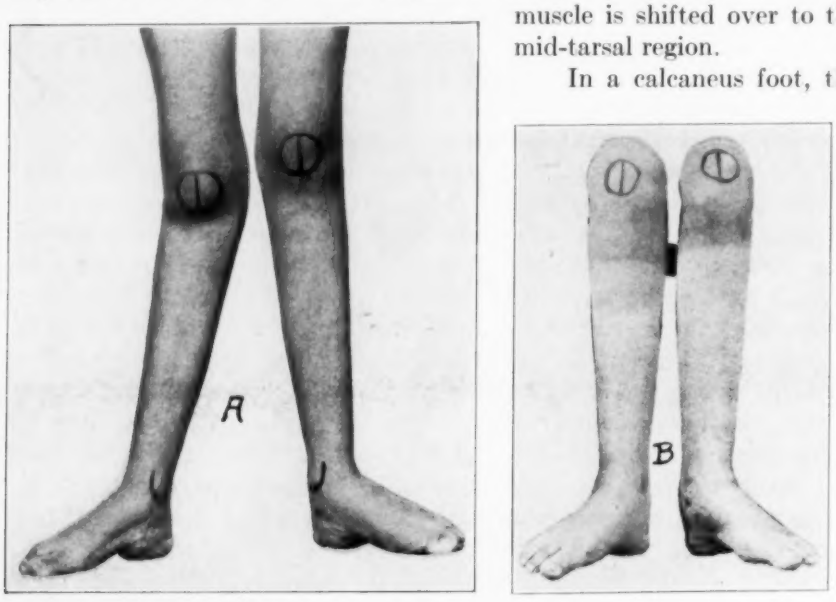

FIG. 5

A: Photograph on admission, showing a combination of bilateral tibial torsion and bilateral knock-knee in essentially flail lower extremities.

B: One month following bilateral stabilization in which both feet were placed in correct relationship to the malleoli and the ankle joint without regard to the deformity in the remainder of the extremity.

C: At time of discharge from the hospital after external torsion and knock-knee had been corrected on each side by osteotomy of the tibia. Note that the foot and the entire extremity are now in satisfactory alignment and afford a straight line of weight-bearing.

transplanted into the calcaneum, and any drop-foot tendency is controlled by the type of stabilization employed. Originally the tendon of the tibialis anterior was not transplanted into the calcaneum, but was shifted over to the mid-tarsal region, and some recurrent calcaneus deformities developed. In some cases it was excised, but it often functions as an excellent transplant in spite of the fact that it has a directly opposite action, and it should always be utilized.

In simple equinus feet, the peroneal tendons are transplanted to the mid-tarsal region if they reveal sufficient power. If they are too weak for transplanting forward, the tendons are excised or transplanted to the calcaneum along with the tendon of the tibialis posterior. If any power remains in the tibialis anterior, the tendon is shifted to the mid-tarsus, which relieves the stretch on this muscle, and it frequently happens that this muscle increases in power after the deformity has been corrected. If the toe extensors are present, the extensor hallucis longus is shifted back as described previously.

ASSOCIATED DEFORMITIES IN REMAINDER OF EXTREMITY

Recurrent deformities were seen as a result of associated malformations in the remainder of the extremity in forty-three instances. External torsion in the tibia was responsible for eighteen of these, and this associated deformity is seen almost exclusively in varus feet. (See Figures 5 and 6.) The foot should always be stabilized in proper alignment with the two malleoli and the ankle joint. When tibial torsion is present, the foot and ankle are left in a position of external rotation. This is corrected later by a transverse osteotomy of the tibia in its upper fourth, by merely rotating the distal fragment inward until the foot and ankle are placed in proper relationship to the knee joint. Some of these secondary deformities of the foot were the result of uncorrected tibial torsion, and some resulted from torsion which itself recurred after the extremity had been properly aligned at operation. The recurrent deformity in this type of foot is unquestionably

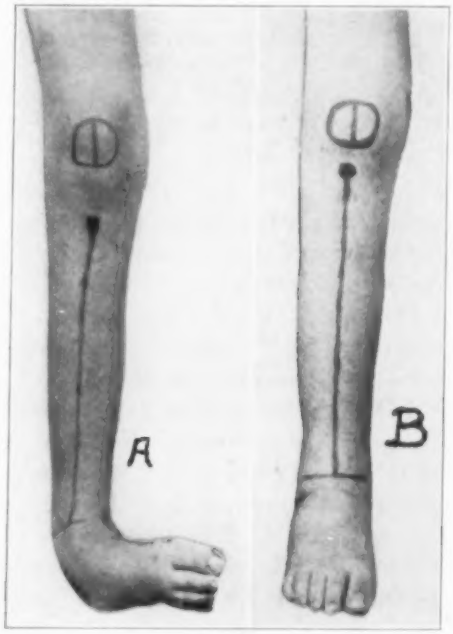

FIG. 6

A: Extreme varus deformity with associated external torsion of the tibia.

B: After stabilization of the foot, properly aligned with the two malleoli and the ankle joint, and correction of torsion later by osteomy of the tibia.

FIG. 7

A: Valgus deformity associated with an exaggerated bow of the lower third of the leg.

B: After stabilization of the foot in correct relationship to the ankle joint. In order to correct the valgus element completely in such instances, it is necessary to place the foot in a position of relative inversion.

C: End result following osteotomy of the tibia and the fibula in their lower thirds in order to correct this inversion, to restore a satisfactory weight-bearing surface to the foot, and to realign properly the extremity as a whole.

the result of an abnormal line of weight-bearing. There is always an attempt on the part of the patient to hold such a foot in a correct position in walking, either by internally rotating the entire extremity, or by twisting the foot inward. Various theories have been advanced for the explanation of tibial torsion and the mechanism of its development, but no adequate proof can be established that any one theory is correct. Yet, tibial torsion is encountered so frequently that its existence and its importance cannot be doubted. In the primary deformity, it is often difficult to determine whether the torsion or the varus element appeared first. In many instances they may occur simultaneously, each tending to increase the other. The foot is inverted as a result of this abnormal line of weight-bearing, and the weight is shifted to the outer border of the foot. In the original deformity, the shift takes place chiefly at the talocalcanean joint, and is prevented from rotating in the opposite direction by the contour of the articulations between these two bones. In the recurrent deformity, the change is usually primarily in the forefoot.

Simple knock-knee produced recurrent deformities in five feet. This usually produces a valgus deformity which is likewise the result of an abnormal line of weight-bearing. The foot is in a position of relative eversion as a result of this malformation, and the pressure in weight-bearing will usually cause this to increase to a fixed valgus deformity. In an adequately stabilized foot, an abduction of the forefoot alone may result. Varus deformities can occur as a result of knock-knee, and this is usually the result of an effort on the part of the individual to place the weight-bearing surface of the foot flat on the floor. This requires inversion of the foot, and a position of true inversion is substituted for one of relative eversion.

A combination of knock-knee and tibial torsion was responsible for recurrences in seventeen instances. (See Figure 5.) Both varus and valgus deformities were encountered in this group, and the type of recurrence apparently depends upon which of the two associated deformities is the more marked.

Recurrent deformities have been found secondary to a definite bow in the lower third of the tibia and fibula in three cases. (See Figure 7.) This type of bow is occasionally seen prior to stabilization in valgus feet. The talus is held in line with the lower end of the tibia and fibula by the two malleoli, and the foot deformity occurs at the talocalcanean joint. Therefore, since the ankle joint itself is inverted as a result of the bow, the entire foot has to be placed in a position of inversion at the time of the stabilization if it is placed in correct relationship to the ankle joint. If this is not taken into consideration at the time of arthrodesis, the foot itself is still in a position of eversion, and the valgus deformity recurs as a result. If the foot is inverted to align it properly with the ankle joint at the time of arthrodesis, the bow must be corrected later to place the weight-bearing surface of the foot in a horizontal plane. If this is not done, weight is transmitted to the outer border of the foot, and the recurrence is varus in type.

In the stabilization of any foot, it should be placed in correct relationship to the ankle joint, without regard to associated deformities in the remainder of the extremity. The deformities above the ankle are then corrected in order to place the foot and extremity in correct relationship. Tibial torsion is corrected by simple osteotomy of the tibia as previously described. Knock-knee deformities are corrected by osteotomy of the femur or of the tibia, or of both if indicated. The bow in the lower third of the leg can only be corrected by osteotomy both of the tibia and of the fibula at the maximum point of the bow.

PATIENT TOO YOUNG WHEN STABILIZATION WAS DONE

Secondary deformities have been encountered in four cases where stabilization performed at too young an age was the only apparent cause for the recurrence. In this entire series only twenty-four feet have been stabilized in individuals below the age of seven years. Of the four patients with recurrences accounted for on this basis, three were six years and one was two years of age.

In the average child, the tarsal bones are too small and their centers of ossification are not developed sufficiently to ensure a solid bony arthrodesis prior to the age of eight years. Such an operative procedure should not be attempted in a child younger than this without determining roentgenographically the amount of bone actually present. Even in children who have reached this age, the feet are occasionally so small that roentgenograms should be obtained in order to prove the presence of adequate osseous development.

NO DEMONSTRABLE CAUSE FOR RECURRENCE

There were only ten feet in which recurrent deformities developed which could not be adequately explained by one or more of the previously mentioned factors. Eight of these were in extremities which were completely flail and required the use of a thigh brace. In such an extremity, it is often difficult to maintain perfect alignment at all times by means of a brace. Any deviation from the mid-line shifts the line of weight-bearing to one side of the foot or the other, and, in so doing, may cause it to tilt sufficiently to initiate the development of a fixed secondary deformity. The only means of controlling such a tendency is to maintain a well-fitting and correctly aligned brace at all times.

SUMMARY

A series of 1100 consecutive foot stabilizations for the correction of deformities associated with residual poliomyelitis has been studied with reference to recurrent deformities. In such recurrences, some form of abnormal muscle pull is the etiological factor most frequently encountered. In order to prevent such secondary manifestations, it is essential that the muscle power on the medial and lateral aspects of the ankle joint be perfectly balanced or completely removed after arthrodesis. Because of the difficulty encountered in estimating exact power in individual muscles, the peroneal and anterior and posterior tibial tendons are now transplanted to the mid-line posteriorly or anteriorly, unless the muscles are known to be completely paralyzed. If transplantation is not needed, the tendons can be excised. The only exception to this is in a cavus deformity, secondary to paralysis of the intrinsic muscles of the foot, in which all the long muscles are known to be normal in power. The exact procedure to be used in each instance obviously depends on the "set-up" in the individual foot.

Among other etiological factors are associated malformations in the remainder of the extremity. Tibial torsion, knock-knee, and an exaggerated bow in the lower third of the leg are the ones usually seen. In the stabilization of any foot, it should be placed in correct alignment with the malleoli and the ankle joint without regard to the other deformities. Procedures necessary for the correction of these deformities are then carried out at a later operation in order to establish a satisfactory line of weight-bearing in the extremity as a whole.

Four feet have shown recurrences as a result of stabilizations performed at too early an age. These can easily be prevented by waiting until the child is at least eight years of age. If the patient is younger than this, or if the foot is quite small, the presence of an adequate amount of bone should be proved by roentgenograms prior to operation.

After recurrent deformities have once developed, they are corrected by restabilization of the foot followed by removal or correction of the etiological factor in order to prevent another such recurrence.

NON-UNION AND BONE GRAFTS *

BY LT. COLONEL NORMAN T. KIRK, M.D., SAN FRANCISCO, CALIFORNIA

When a fracture in a bone fails to unite, non-union exists. For years, six months has been accepted as a sufficiently long period to wait for union to occur. That non-union will occur can frequently be determined before this period of time by the roentgenographic appearance of the bone ends, by the separation of fragments, or by the non-appearance of radiable callus. The type of injury with its destruction of bone, soft parts, and circulation may have been the real cause of non-union; interposition of soft parts, frequent interference with bone healing by repeated early manipulations, overpull, or incomplete immobilization, infection or loss of substance may have played a part in producing it.

The accepted treatment of non-union is the transplantation of an autogenous bone graft. Ordinarily the inner surface of the tibia is used as a free transplant; the crest of the ilium or a portion of the fibula may be likewise employed. The entire fibula may be transplanted, one end at a time, to replace a marked lost substance in its adjacent tibia, as reported by Carrell and others.

Albee developed and popularized the inlay type of graft using his electrically driven saw. Henderson for years has used the "massive" type of graft, transplanting a larger fragment of bone than ordinarily used and fixing it either as an inlay or an onlay to the bone fragments with beef-bone screws. Campbell prefers the massive onlay type, using autogenous bone pegs reinforced at times by a circular wrapping of wire for fixation. Osteoperiosteal grafts, as well as multiple bone chips, have been successfully employed.

The massive type of graft finds favor because it is long, broad, and strong, and, when properly fixed to the fragments with either autogenous bone pegs or beef-bone screws, it immobilizes the fracture site. The medullary canal is reestablished; the bone ends are freshened; and throughout this area is placed cancellous and endosteal bone from the metaphysis of the tibia and from the inner surface of the graft. The success obtained by this method has been well demonstrated.

Let us consider the preparation of the "graft bed". The scar tissue between the bone ends is removed; the bone ends are freshened; and the medullary canal of both fragments is opened. When the onlay-graft method is used, the rounded cortical bone is flattened by chiseling for the reception of the flat tibial graft. It is believed that at least the outer third of the cortex should be removed, so that the blood supply of the "graft bed" will be derived from the medullary circulation and will not be limited to that supplied by the periosteum. This opinion is based on

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Los Angeles, California, January 18, 1938.

Robert Johnson's findings in dog experimentation that the periosteal blood supply nourishes the outer third of the shafts of the long bones and is insufficient in itself to effect healing in a fracture.[1] The inner two-thirds of the shaft is supplied by the nutrient artery and the metaphyseal vessels anastomosing with it, and, when this supply is blocked, non-union occurs.

The author is satisfied, regardless of many theories advanced, that the bone graft primarily acts as a means by which blood circulation is reestablished between the two ununited fragments, and, when and if this happens, union of the fracture occurs.

In non-union following compound fractures in which infection has occurred or osteomyelitis is present, bone-grafting should not be attempted until the wound has been thoroughly healed for at least six months and the roentgenogram is negative for sequestra or other suggestive shadows in the bone. A scar excision should then be performed; all scar tissue should be removed from the skin, from the subcutaneous and muscle layers, and from about the bone ends. If the skin cannot be closed, a pedunculated graft is used to cover the defect. All scar tissue should be removed from the extremity, and the freshened bone ends should be covered by normal muscle, scar-free subcutaneous tissue, and normal skin. If this wound heals *per primam*, the extremity is then subjected to radiant heat and massage for two weeks. If latent infection is not lighted up, one is then warranted in proceeding with the bone transplant. Of 129 cases of non-union following compound fractures, due mainly to gunshot wounds, even when this procedure was faithfully carried out, failure occurred in twenty-two because of lighting up of latent infection. In an equal number of cases infection developed in the wound, but union was fortunately obtained.

The peg type of intramedullary graft has no place in treatment of non-union, nor, for that matter, as a means of internal fixation in a recent fracture, except in the metaphysis of long bones as in the neck of the femur or in the olecranon. The beef-bone peg was outlawed years ago.

In the presence of marked bone atrophy, where the cortex is of egg-shell thickness and contains much fat and many blood vessels, the onlay type of graft cannot be fixed in position, nor can the inlay type be properly secured. Under such conditions, if the bone end is cut away, a massive type of graft, from one-half to three-quarters of an inch broad, can be pushed up into the fatty mass contained within the cortex and, thus secured, its already diminished blood supply is not further disturbed by removal of the surrounding muscle tissue and its periosteum. This is quite different from introducing a peg into the comparatively normal intramedullary canal of cortical bone. Likewise, a self-retaining partially intramedullary graft may be used successfully for non-union and loss of substance in the metacarpal and metatarsal bones.

In the pseudarthrosis type of non-union the bone is often eburnated

FIG. 1-A

FIG. 1-B

Old gunshot wound with loss of substance and marked bone atrophy. A massive-type tibial graft was shoved up into the proximal fragment after removal of the terminal thin cortical shell. The periosteum was first removed from that part of the graft so introduced. The lower end of the graft was fitted into a slot and a pocket which were chiseled into the distal fragment. The graft was thus made self-retaining. A body plaster cast was applied several days before operation.

and avascular. It does not bleed when cut or drilled, and it corresponds to the dense scar tissue of the soft parts. The blood supply is not re-established through such bone, making regeneration impossible. Grafts at times fail when laid through or over such bone, as the blood vessels cannot penetrate it even when the sclerotic bone is drilled or otherwise broken up. This type of bone is better removed, even though loss of substance is occasioned thereby.

In the past the author has generally used the inlay graft of massive type, from one-half to three-quarters of an inch wide and from six to eight inches long, depending on the amount of lost substance or poor bone to be bridged, and being limited as to length and breadth by the size of

the donor bone. The graft should be long enough so that it has twice as much length contact with the normal bone in each fragment as the lost substance or the poor bone to be bridged. This may not always be mechanically possible.

In the forearm bones, the "fish-tail", the "diamond", and the inlay types of grafts have too often failed because the bone transplanted was not sufficiently large. The writer prefers to cut away half of the shaft of each fragment, substituting a graft the width of the forearm bone at its greatest medullary diameter and filling in the whole space with a tibial graft of this size.

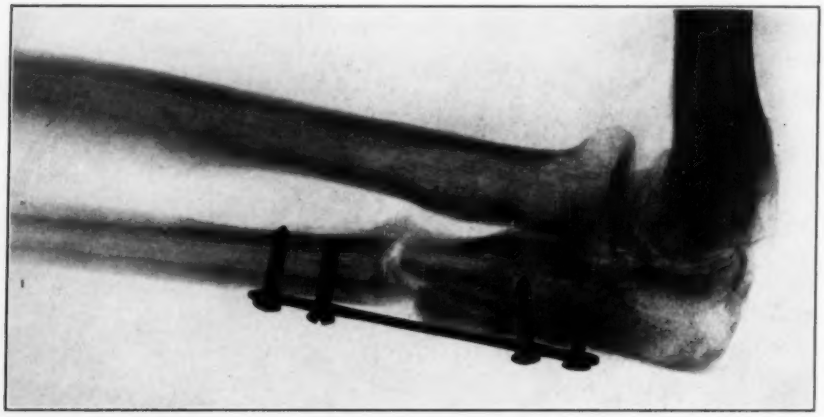

FIG. 2-A

Non-union five months after open reduction and plating of simple comminuted fracture of the upper third of the ulna, complicated by dislocation of the head of the radius and fracture with displacement of the lateral condyle of the humerus and the capitellum. The trochlea was free in the joint and was removed at the original operation.

FIG. 2-B

Union ten weeks after massive type of self-retaining graft. Half of the shaft of the ulna was cut away. The ends of the cortex were notched. The tibial graft slid in from the side was made self-retaining and was further fixed with two autogenous bone pegs.

Kangaroo tendon or chromic catgut, when used to fix the graft in position in cases of non-union resulting from war injuries, frequently was not absorbed, acted as a foreign body, and caused sinus formation. For this reason, a self-retaining type of graft was developed. An inlay bed was cut with the Albee saw. The cortical bone at each end of the gutter was then beveled from above downward with a small osteotome. The graft was cut slightly longer than the gutter, and its two ends were beveled from above downward. The graft was placed in the gutter with one end fixed under the beveled cortex; the other end was then jimmied down into the gutter. With a bone set and mallet, the graft was slid toward the end last introduced. The graft then became locked into position. The leg could be picked up and vigorously shaken, and the graft maintained its position. The base of the graft bed at the fracture site was left sufficiently high to support the graft and to bring the three layers of bone,—periosteum, cortical bone, and endosteum—into apposition.

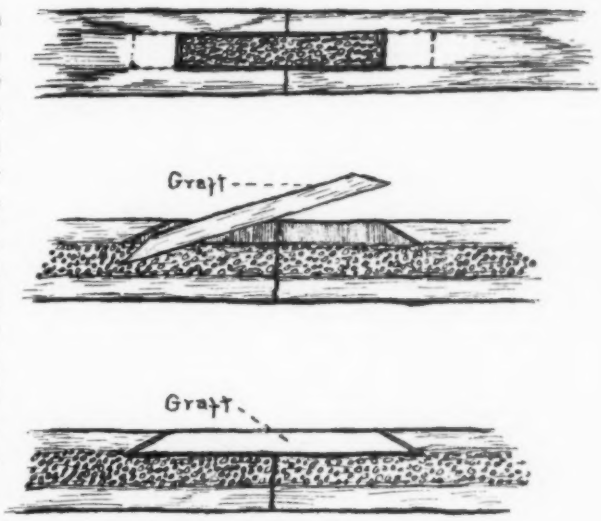

FIG. 3-A

Diagrammatic representation of self-retaining inlay graft. The cortical bone at the end of the gutter is beveled from above downward with an osteotome. The graft is cut the width of the gutter and slightly longer, and is beveled at both ends from above downward. The graft bed is cut to proper depth to support the graft at its center. Both ends of the graft lie over the normal medullary canal.

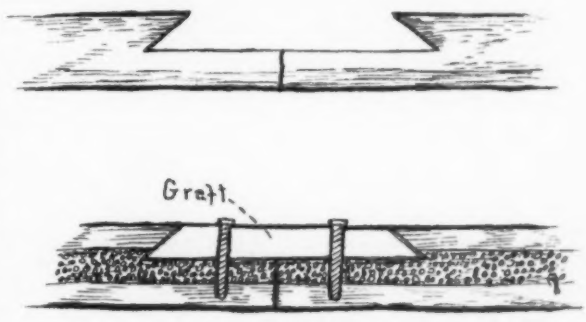

FIG. 3-B

Radius or ulna. Here half the shaft of each fragment is removed as illustrated. A graft is cut to fit the defect. It is slid in from the side, anchoring both ends below the undercut cortical bone, and is further fixed with beef-bone screws or autogenous pegs if lateral play of the fragments is feared.

The same method, using the massive graft, was employed in the forearm. The undercutting of each fragment was done by the motor saw;

the graft ends were beveled; and the graft was slid in from the side. If further fixation was needed, beef-bone screws were used.

From the fixation afforded and the results obtained, the onlay massive graft is accepted as the method of choice for non-union in the humerus and in the femur. The author prefers the self-retaining massive inlay in the tibia, but in the radius and in the ulna the self-retaining massive graft described. Absolute fixation of the graft to its bed is essential or death of the graft will occur. The graft must snugly fit its bed throughout. Autogenous bone pegs are theoretically more ideal than beef-bone screws, but mechanically they are more difficult to use and may or may not afford as good fixation. The writer has never used metal screws or wire to hold a graft in position, and has seen quite a few failures directly attributable to their use. The self-retaining graft gives ideal fixation.

Secure plaster fixation is essential, and, as soft-tissue atrophy occurs, casts must be changed to ensure immobilization. In bone-grafting operations on the humerus it is well to apply a body cast two or more days in advance to see that it properly sets, fits, and is comfortable. The arm piece is easily applied to the body cast after the operation is completed. Bivalved premade casts do not afford proper immobilization. Immobilization is continued until roentgenographic examination shows that the graft has become an integral part of the bone. From the time element, in an uncomplicated non-union this may occur almost as rapidly as the healing of a primary fracture. In old compound fractures with loss of substance, where the general circulation of the extremity has been markedly impaired, immobilization will have to be continued from two to three times as long. After removal of the cast, a properly fitted supporting brace is substituted and worn until union is firm.

1. Johnson, R. W., Jr.: A Physiological Study of the Blood Supply of the Diaphysis. J. Bone and Joint Surg., IX, 153, Jan. 1927.

TRANSPLANTATION OF THE FIBULA IN THE SAME LEG *

BY W. B. CARRELL, M.D., DALLAS, TEXAS

TRANSPOSITION OF THE FIBULA FOR LOSS OF THE TIBIAL DIAPHYSIS

Perfection of technique in massive bone-grafting has reduced the indication for transposition of the fibula to a very limited field. Extensive loss of bone following radical surgery or sequestration in osteomyelitis presents a problem which in some instances is best solved by the fibular graft. After a long period of infection, the cicatricial tissue between the remaining portions of the diaphysis has little blood supply and is a poor bed for a massive free graft. The fibula, when transposed, retains much of its blood supply, and restoration is more like union of a fracture than revascularization of a bone graft. In some cases it is not even necessary to expose the entire fragment of the tibia, and the contact may be made with a minimum of trauma. This permits an early operative approach. Finally, should there be recurrence of infection, transposed bone is more likely to survive.

The procedure seems indicated definitely in two groups of cases. The first group includes those cases in which there is loss of the tibial diaphysis, even in moderate extent, but with a history of frequent reinfection. The fibula with established blood supply will live in the presence of infection. The second indication is for extensive loss of the diaphysis. With only short stubs of metaphysis remaining at each end, the fibular transplant serves well.

The following case reports illustrate the value of the method.

CASE 1. L. S., female, aged twelve years, was examined in April 1937, because of a deformity of the right leg resulting from moderate loss of the tibial diaphysis following osteomyelitis. She gave a history of frequent recurrences of infection.

On April 30, 1937, the lower end of the fibula was sectioned one and one-half inches above the malleolus and transplanted into the lower tibial fragment. The remaining portion of the fibula at the ankle was left to fuse at the upper end with the tibia to maintain ankle stability. There was some infection reaction with sinus drainage after three weeks; the sinus closed two months later.

A second-stage operation was performed on January 7, 1938. The proximal end of the fibula was exposed through a high anterolateral incision. The soft tissue, including the peroneal nerve, was reflected subperiosteally, which exposed also the plateau and lateral surfaces of the tibial diaphysis. The neck of the fibula was found firmly fused with the tibia through an area of approximately one centimeter. The part of the fibula above the fused area, which included the head and a short portion of the shaft, was excised and used as a graft to supplement the fusion. The tibial metaphysis and the adjacent surface of the fibula were denuded, and one end of the graft was inserted into the tibia; the other end rested firmly against the fibula. Small chip grafts were added for contact.

When last seen, on April 1, 1938, there was firm union.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Los Angeles, California, January 18, 1938.

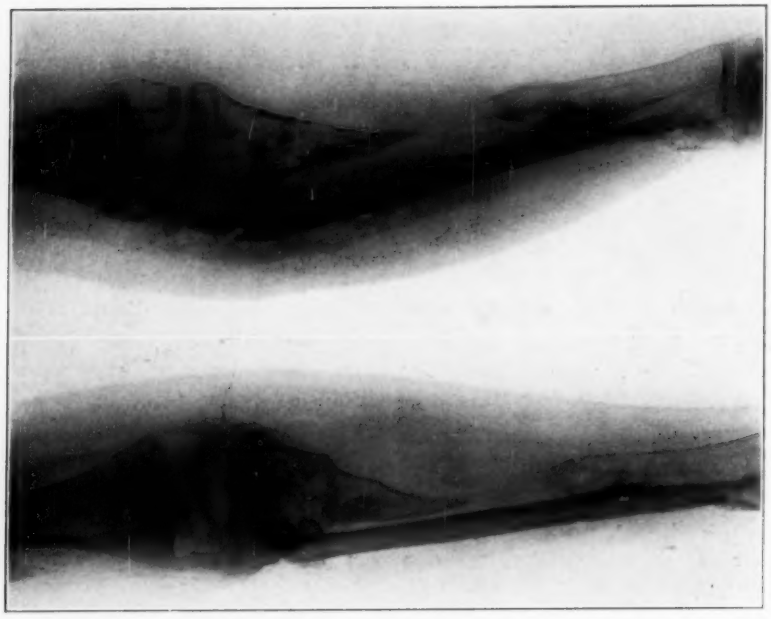

FIG. 1-B

Anteroposterior and semi-anteroposterior views immediately following second operation, showing upper end of fibula, and lower end transposed eight months previously.

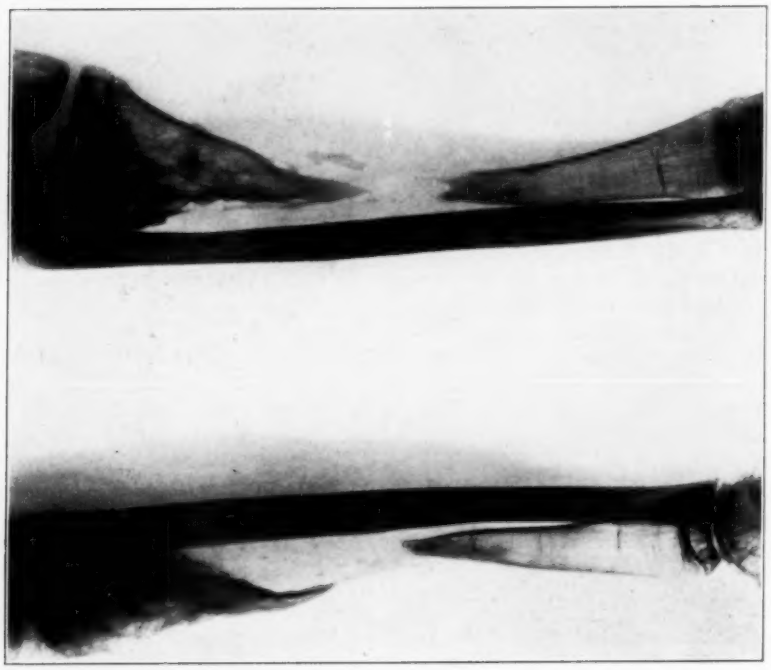

FIG. 1-A

Case 1. Lateral and anteroposterior views, showing loss of tibial diaphysis due to osteomyelitis.

FIG. 2-A

Case 2. Lateral and anteroposterior views, showing loss of tibial diaphysis following osteomyelitis.

FIG. 2-B

Patient before operation.

FIG. 2-C

Lateral and anteroposterior views, seven years after operation. Patient can now walk.

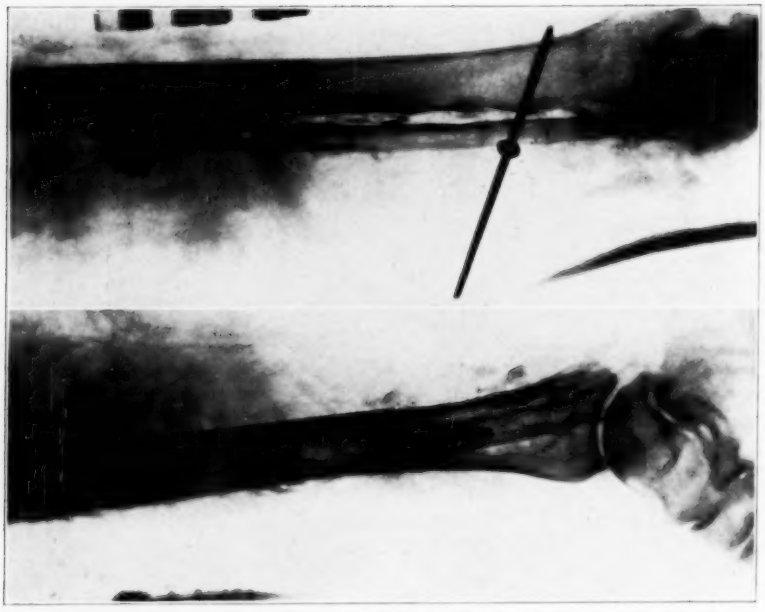

FIG. 3-B

Lateral and posterior views, showing transposition of the upper end of the fibula to the ankle for mortise stabilization.

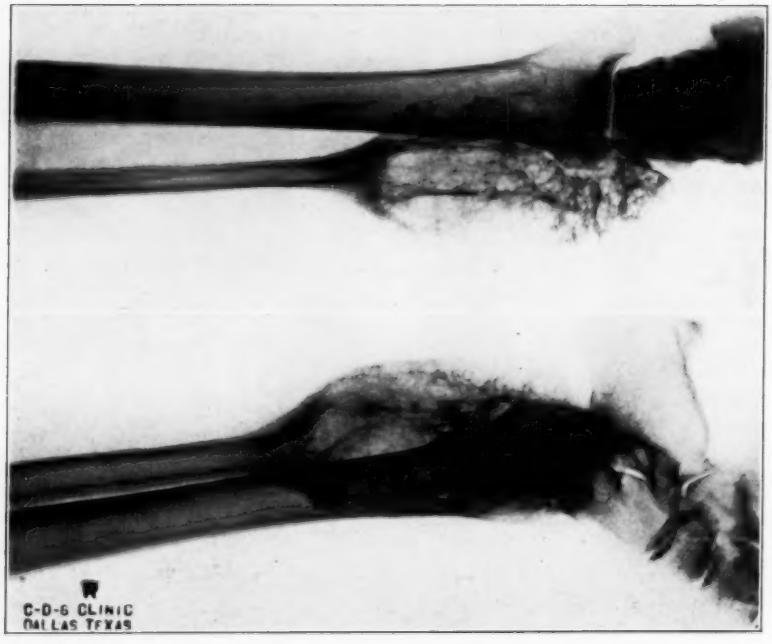

FIG. 3-A

Case 3. Lateral and posterior views, showing hemangioma of the lower end of the fibula.

CASE 2. N. H., female, eight years of age, was seen on April 2, 1930, because of extreme deformity of the left leg following osteomyelitis. Examination showed loss of the entire diaphysis with four inches of shortening. The patient gave a history of severe infection starting two years previously with spontaneous drainage three weeks after onset and subsequent extrusion of many large and small sequestra. The infection continued about two years with drainage most of the time.

On admission, the sinuses near the knee had been healed for several months, and one near the ankle had been closed for thirty days. The patient had never been operated upon, although there was a heavy mass of scar on the anterior surface of the leg caused by multiple sinuses. The extreme deformity with four inches of shortening made it desirable to stabilize the leg as early as possible. Transposition of the fibula was believed to be indicated.

FIG. 3-C

Lateral and posterior views, six months after operation. Twelve months after operation, union between the graft and tibia was firm and ankle function was good.

At operation, on May 2, 1930, the entire upper end of the fibula was released, and, through the same incision, the lateral surface of the tibial fragment was exposed behind the anterior tibial muscles. A large drill hole was made to receive the fibula, and the latter, without periosteum, was levered into position. The fibula extended very close to the epiphyseal cartilage. Union occurred without infection. Because of continued sinus drainage near the ankle, the second stage of the operation was postponed for sixteen months.

A second-stage operation was performed on September 28, 1931. There had not been any drainage for the past four months. The entire lower end of the fibula was released and set through the remnant of the tibial epiphysis into the body of the astragalus. In this case, ankle motion was lost because of infection which had destroyed a part of the tibial epiphysis with invasion of the joint. The objective was a weight-bearing leg to carry the patient through childhood, with the anticipation that later amputation of the leg would be required. Healing was complete with fusion in three months and no infection.

This case is the type most suitable for transposition of the fibula. A massive free-transplant operation would have been hazardous until long after the date of the second-stage operation.

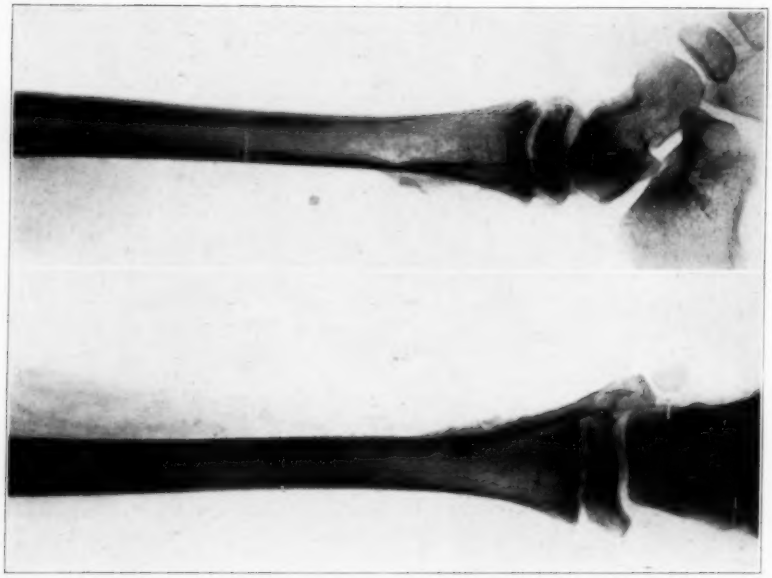

FIG. 4-B

Posterior and lateral views, showing upper end of fibula moved to lower end for preservation of ankle mortise.

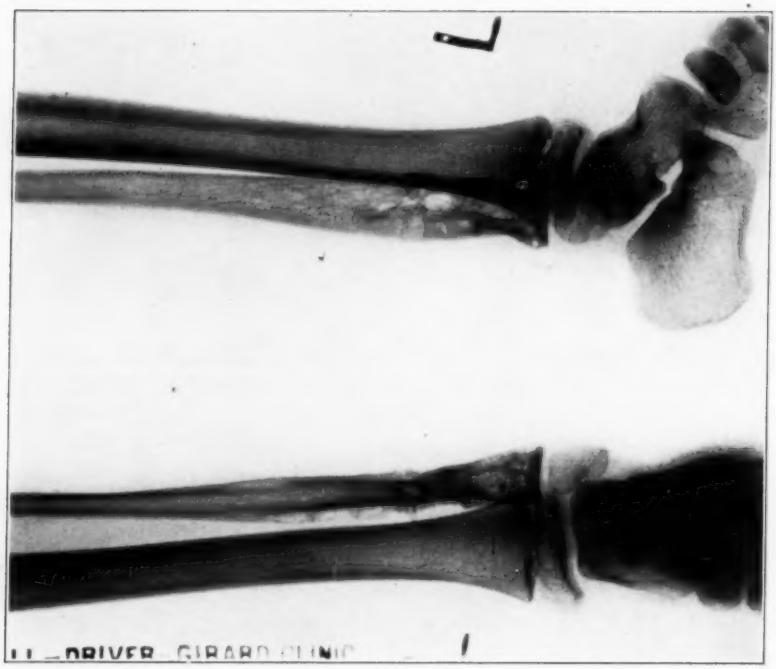

FIG. 4-A

Case 4. Posterior and lateral views, showing Ewing's sarcoma of the fibula.

FIG. 4-C
Two years after operation.

TRANSPOSITION OF THE FIBULA TO RESTORE ANKLE MORTISE

The size and shape of the head of the fibula are well adapted to support the lateral side of the ankle when transplanted. The procedure is illustrated in the following case reports.

CASE 3. Mrs. R.C.K., aged forty-five years, was seen because of a slight swelling on the outer aspect of the right ankle. The clinical diagnosis was giant-cell tumor.

At operation, the lower third of the fibula, with the tumor, was removed. The proximal portion was released through a separate incision over the head of the fibula by stripping the soft tissue from the periosteum. The bone was then pulled through the lower incision and transplanted at the ankle. The attachment of the biceps was sutured to the fascia lata and capsule of the fibula. The fibular graft and the lateral side of the tibia were prepared by roughening the surfaces which would be in contact. In placement, the head of the fibula was against the side of the astragalus and formed an outer support for the ankle. The graft was held in firm position through the use of a special screw, which compressed it against the tibia.

An interesting fact in the history, although irrelevant to the subject under discussion, is that five months after operation a tumor was discovered in the femoral condyle of the same leg. Two months prior to discovery, the patient had sustained an injury to this portion of the knee,

and a slight swelling had appeared, lasting a few days. This swelling had reappeared after three weeks. Roentgenograms of the knee revealed a tumor with the appearance of a benign giant-cell growth. Roentgenotherapy was given. The pathological diagnosis of the tumor removed from the ankle was hemangioma of the capillary type.

CASE 4 (Registry of Bone Sarcoma, No. 1943). J. A. S., female, six years of age, two months prior to examination, had received a severe bruise on the outer side of the left ankle. The swelling had lasted several days, and soreness had persisted for the entire period. Two weeks before examination the swelling had reappeared, but the mother stated that it seemed a little different in that it had a firmer character.

Examination revealed a firm fusiform thickening over the lower two inches of the fibula, which, in the roentgenogram, had the appearance of Ewing's sarcoma. The suspected diagnosis was proved by biopsy. Roentgenotherapy was instituted, and six months later recession of the tumor was evident roentgenographically.

At operation, on February 4, 1935, the lower end of the fibula and the tumor were excised and the upper end of the bone was transposed for support of the ankle mortise. Great care was exercised to preserve the upper epiphysis without injury and to transplant the graft in such position that the shaft of the tibia would not carry it up the leg in its future growth. The graft was imbedded into the tibia just proximal to the epiphyseal plate, and directed away from the epiphysis as it crossed the ankle joint.

Two years after operation there was two centimeters of shortening in the leg, probably due to the roentgenotherapy. (Fourteen treatments were given during the six months before operation.) The graft had grown in length and in size and until that time the epiphyseal line was distinctly shown in roentgenograms. It had the same relationship to the ankle as when introduced, and stability was good.

Of interest in tumor therapy is the unanimous opinion by members of the Registry in regard to the biopsy diagnosis of Ewing's sarcoma. After roentgenotherapy for six months, the specimen removed at operation was free from any structure resembling tumor tissue.

BONE GRAFTS IN UNUNITED FRACTURES *

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From the Section on Orthopaedic Surgery, The Mayo Clinic

Bone-grafting came into general use in the treatment of ununited fractures about 1912. The basis for the present paper is a review of the records in all cases in which transplantation of bone for ununited fractures was carried out at The Mayo Clinic during the twenty-five-year period from 1912 to 1936, inclusive. There were 583 patients so treated; the end results are known for 530. Of these, 462, or 87 per cent., were treated successfully, and bony union was obtained; whereas sixty-eight, or 13 per cent., were not so fortunate, and the results must be classified as failures. Except in a few instances, wherein a graft from one individual was transplanted in another, an autogenous graft was used.

Not all ununited fractures were treated by a bone-grafting procedure. Certain fractures of the humerus, for example, were "stepped", and side-to-side apposition was obtained; others, particularly ununited fractures of the lower third of the femur and, occasionally, of the tibia, were freshened and lined up. In some cases the malposition and deformity were such complicating factors in the operation that, to save time, metal plates or bands were used for fixation. The use of metal is frowned upon by many authorities, but difficult operations, with the accompanying trauma and long exposure of tissues, definitely raise the percentage of infection; therefore, in order to shorten the procedure, metal may well be employed. The end results in our cases at The Clinic in which we did rely on metal have justified the procedure.

Hindsight will only be better than foresight if we study our failures and mistakes, so, with the aid of Dr. Herman Young, we picked out from the 530 traced cases the records of the sixty-eight patients unsuccessfully treated and studied them closely. This study has served to emphasize certain very definite dangers and unfavorable factors,—some of them avoidable, others unavoidable. Although we were previously aware of them, there is nothing like cold figures to drive home the truth. The percentage of failures is higher than the author would like to have it, but, in all fairness and not in apology, it must be pointed out that the period covers the early days of bone-grafting when the technique was not well developed. Also, in many of these patients the fractures had existed in a state of non-union for years; many patients had been operated on previously, some a goodly number of times; and a large percentage of the fractures had been caused by severe trauma and had been previously infected. There are many factors concerned in the management of these cases that

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Los Angeles, California, January 18, 1938.

the writer would like to discuss, but to obviate the possibility of confusion, the present paper will be confined to what he considers the major points.

SEX AND AGE

Sex is of no importance; as might be expected, most of the patients were males. Age is of definite importance. As will be pointed out in our series of cases of fracture of the tibia, the percentage of poor results is notoriously high for ununited fractures sustained at birth, in early infancy, in childhood, or even in adolescence. While ununited fractures in the elderly are not as easily dealt with as those occurring in middle life, they are quite adaptable to bone-grafting procedures provided the patient's general condition is good. As a matter of fact, old age is no bar to sound surgery of any kind, provided shock (which is usually caused by excessive loss of blood) and trauma incident to prolonged operations are avoided.

GENERAL CONDITION OF PATIENT

The health of the group of patients under consideration was remarkably good and poor results could not be attributed to their general condition. Syphilis has often been mentioned as a factor in the production of ununited fractures, but this has been far from our experience, nor is there any proof that it was a factor in the failures in this series. Only two patients gave positive histories of syphilis, and both had negative flocculation tests. Calcium and phosphorus studies were made in a great many cases, but the values were practically normal in all. Phosphatase has been estimated of late years, but it is of no clinical significance. Ununited fractures due to osteogenesis imperfecta are truly difficult to treat successfully. If a diabetic patient is to be operated on, the operation must be well planned, for such patients do not stand prolonged operations at all well and the cooperation of an internist should be secured to watch over the postoperative course.

INITIAL INJURY

When the injury is of a very severe type—such as a crushing, twisting, or bruising trauma—so much damage is done to the bone and the soft parts that the reparative power of the bone may be permanently kept below par. We believe this was a prominent factor in many of our cases with poor results. Damage to the soft parts is very important,—in dealing with fresh fractures, we have seen many badly comminuted ununited fractures, unaccompanied by injury to the soft parts, that finally united even though union was often delayed. The initial injury may have been a compound fracture, leading to the production of severe infection and scarring, and causing a decreased blood supply to the surrounding tissues and, consequently, to the bone. Scar tissue in the operative field is particularly bad, for sloughs may follow, which provide an ideal field for infection carried by the blood stream. A considerable number of our cases of infection developed late in just that way.

LENGTH OF TIME UNUNITED FRACTURE EXISTED

Some fractures still show evidence of an attempt at repair as long as two or three years after injury, whereas a fracture only a few months old may exhibit complete inertia. In this study the author has attempted to make no sharp differentiation between delayed union and non-union, because he believes that the length of time during which the fracture has been ununited is of comparatively minor importance. Union has been readily secured in fractures that have existed for as long as eighteen years, and union has failed in fractures that have existed only a few months. Much depends upon the condition of the bone fragments, the blood supply, the amount of scar tissue present, etc. Osteoporosis consequent to non-use is of little importance and can be disregarded, but osteoporosis accompanying osteogenesis imperfecta is unfavorable and should be overcome as much as possible before operation.

The question is often asked: How long should one wait before performing transplantation of bone for an ununited fracture? The opportunity of choosing the time has by no means been our privilege, because patients with such fractures come from widely scattered areas and one seldom sees a delayed union in one's own practice. This series of cases, therefore, does not answer that question, but the longest time that an ununited fracture had existed in our series was nineteen years; the shortest, two and a half months; and the average duration, three years.

In so far as the condition of the bones is concerned, the writer believes that an ununited fracture which has been present for years offers practically as favorable an opportunity for bone-grafting as does one of shorter duration, although the accompanying deformity—that is, the malposition of the fragments, particularly in the lower extremity—is often a problem in itself and does very definitely complicate the procedure. Consequently, other things being equal, one would expect in any given two series studied for comparison that the series with an average shorter duration of non-union would give somewhat better results than the one composed of cases of fracture of longer duration.

PREVIOUS TREATMENT

The scarring following previous operations and perhaps infection was in many cases an unfavorable and hazardous condition that could not be avoided. The incision should always be made through the soundest tissue possible. In previously infected cases, the longer the time between the cessation of all drainage and the operation, the better the chances of avoiding subsequent infection and drainage. A smooth, movable, cool, white scar is desirable. We now make it a rule never to operate on a patient less than six months, and seldom under a year, after the cessation of drainage. Operation should be postponed as long as the scar remains red and inflamed.

THE BONE INVOLVED AND THE SITE OF FRACTURE

As bones differ in their shape and size and so present different me-

TABLE I

SUMMARY OF CASES OF UNUNITED FRACTURES TREATED BY BONE GRAFT AT THE MAYO CLINIC FROM 1912 TO 1936 INCLUSIVE

Bone Involved	Total Cases	Cases Traced	Results	
			Successful	Failure
Femur	100	92	72	20
Tibia	233	218	197	21
Humerus	100	91	78	13
Radius	70	57	53	4
Ulna	30	28	25	3
Radius and ulna	44	39	33	6
Clavicle	5	4	3	1
Metatarsal	1	1	1	0
Total	583	530	462 (87 per cent.)	68 (13 per cent.)

chanical problems, there is a consequent variation in the percentage of successful results. In this series the highest percentage of failures occurred in fractures of the femur. The site of the fracture in the bone—whether in the upper, the middle, or the lower third—is of considerable importance. In the ninety-two cases of ununited fracture of the femur, including the femoral neck, in which patients were traced there were

TABLE II

UNUNITED FRACTURES OF THE FEMUR TREATED BY BONE GRAFT (1912–1936)

Site of Fracture	Total Cases	Cases Traced	Results			
			Successful		Failure	
			No.	*Per Cent.*	*No.*	*Per Cent.*
Neck	61	57	45	79	12*	21
Upper third	9	9	7	78	2	22
Middle third	22	20	16	80	4	20
Lower third	8	6	4	67	2	33
Total	100	92†	72	78	20‡	22

* Includes 3 cases of postoperative infections with loss of grafts and 9 cases in which the grafts became absorbed and fractured.

† 17 per cent. of total of 530 traced cases.

‡ 29 per cent. of total of 68 failures.

twenty failures; in the 218 cases of fracture of the tibia, twenty-one failures; in the ninety-one cases of fracture of the humerus, thirteen failures; in the fifty-seven cases of fracture of the radius, four failures; in the twenty-eight cases of fracture of the ulna, three failures; in the thirty-nine cases of combined fractures of the radius and the ulna, six failures; and in the four cases of fracture of the clavicle, one failure. (See Table I.)

Fractures of the Femur

There were fifty-seven cases in which fractures of the neck of the femur were treated by bone grafts and in which the results are known. The results were successful in forty-five, or 79 per cent., of the cases and failures in twelve, or 21 per cent. (See Table II.) Failures in the treatment of fractures of the neck of the femur are very discouraging when they do occur, for the patients are usually elderly and the time spent is regrettable, since the life expectancy of such patients is naturally low. This much can be said: The head of the femur must be viable; there must be sufficient femoral neck left to work with; the fibrous tissue of the union must be dissected out; and the bone ends must be freshened and accurately fitted if the maximal results are to be obtained. Postoperative fixation must be as complete as possible for at least three months. A review of our records made it plain that our failures were accounted for mostly by non-fulfillment of the foregoing conditions. If the fracture surfaces are not held closely together, the bone graft atrophies and breaks at the site of fracture, for it will not bridge the gap. We had three postoperative infections in this group that were factors in the failures.

In so far as fractures of the femoral shaft are concerned, whether the fracture is in the upper, the middle, or the lower third seems to be of some importance, because, in the lower third, the percentage of failures was 33 as against 20 and 22 in the middle and upper thirds, respectively. However, only eight bone grafts were done on the lower third of the femur. The reason that there were so few is that there is such a breadth of bone in that location that we are content to secure good, broad, bony apposition of the fragments and to maintain it with a metal plate. The results of this procedure are very good, and the technique is much simpler than if a bone graft is used.

Fractures of the Tibia

Our experience with ununited fractures of the tibia clearly showed that the age of the patient can be a definite factor. Whereas the percentage of failures for the total number was 10, if the cases of individuals less than twelve years of age are excluded (nine cases or 43 per cent. of the total tibial failures), our percentage of good results jumps to 94 per cent. with failure in only 6 per cent. Treatment of the twenty-two fractures in the upper third was successful in all cases, whereas in the eighty-nine fractures in the middle third failure resulted in 8 per cent. and in the 107 fractures in the lower third treatment failed in 13 per cent., indicating that the

TABLE III

UNUNITED FRACTURES OF THE TIBIA TREATED BY BONE GRAFT (1912–1936)

Site of Fracture	Total Cases	Cases Traced	Results			
			Successful		Failure	
			No.	*Per Cent.*	*No.*	*Per Cent.*
Upper third	24	22	22	100	0	0
Middle third	92	89	82	92	7	8
Lower third	117	107	93	87	14	13
Total	233	218*	197	90	21†	10
Patients less than 12 years old	20	19	10	53	9	47
Adults	213	199	187	94	12	6

* 41 per cent. of total of 530 traced cases.
† 31 per cent. of total of 68 failures.

lower third is the most unfavorable site in the tibia for this procedure. There were two failures in cases of adolescents with fractures in the middle third, and seven in cases of those with fractures in the lower third. (See Table III.)

Fractures of the Humerus

The site of the lesion is of prognostic importance in ununited fractures of the humerus. In the twelve cases of fracture in the upper third there were two failures; in the forty-three cases of fracture in the middle third, two failures; and in the thirty-six cases of fracture in the lower third, nine failures. The percentage of failures for this whole group was 14. (See Table IV.)

Ununited fractures of the lower third of the humerus are thus shown to be an unfavorable group, and the different steps of the operation must, therefore, be carefully planned. All evidence of previous infection must have disappeared before treatment is undertaken. Adequate contact of the fragments and fixation of the bone graft must be secured, particularly to the lower fragment which is often quite short and difficult to control, owing to stiffness of the elbow. Infections seemed to have been definitely the cause of four of our failures, and these infections developed in the five cases in which there had been previous infections; in only one case of this group did healing take place by primary intention. Pressure is too often put upon the surgeon to operate because the patient can ill afford to wait, being far from home, etc., but to yield before all evidence of inflammation has subsided is to regret it later. In four of the cases of failure, while sepsis was not present, the graft fractured during convalescence, probably because contact of the fragments was faulty. In one case an

TABLE IV

UNUNITED FRACTURES OF THE HUMERUS TREATED BY BONE GRAFT (1912–1936)

Site of Fracture	Total Cases	Cases Traced	Results			
			Successful		Failure	
			No.	*Per Cent.*	*No.*	*Per Cent.*
Upper third	13	12	10	83	2	17
Middle third	46	43	41	95	2	5
Lower third	41	36	27	75	9*	25
Total	100	91	78	86	13	14

* Previously infected in 5 cases, and in 4 of these 5 cases became infected after operation. In none of cases without previous infection did infection develop following operation.

accident in handling while taking a roentgenogram about eight weeks post-operatively resulted in fracture of the graft.

Fractures of the Radius Alone

In this group there were fifty-seven traced cases with four failures, or 7 per cent. (See Table V.) There were fourteen cases of fracture in the upper and middle thirds with no failures, and forty-three in the lower third with four failures. In cases of fracture of the lower third of the radius it is difficult to obtain correct alignment because of ulnar deflection of the upper end of the lower fragment with consequent radial deflection of the hand and the wrist. However, such deformity must be corrected to obtain good function, and adequate contact of the graft with the lower fragment must be secured.

TABLE V

UNUNITED FRACTURES OF THE RADIUS TREATED BY BONE GRAFT (1912–1936)

Site of Fracture	Total Cases	Cases Traced	Results			
			Successful		Failure	
			No.	*Per Cent.*	*No.*	*Per Cent.*
Upper third	3	1	1	100	0	0
Middle third	17	13	13	100	0	0
Lower third	50	43	39	91	4	9
Total	70	57	53	93	4	7

TABLE VI

UNUNITED FRACTURES OF THE ULNA TREATED BY BONE GRAFT (1912–1936)

Site of Fracture	Total Cases	Cases Traced	Results			
			Successful		Failure	
			No.	*Per Cent.*	*No.*	*Per Cent.*
Upper third	10	10	9	90	1	10
Middle third	13	13	12	92	1	8
Lower third	7	5	4	80	1	20
Total	30	28	25	89	3	11

Fractures of the Ulna Alone

In this group there were twenty-eight traced cases with three failures, or 11 per cent. There were ten cases of fracture in the upper third, with one failure; thirteen in the middle third, with one failure; and five in the lower third, with one failure. (See Table VI.) Here again fractures in the lower third seem to be the most difficult to treat.

Fractures of the Radius and the Ulna Combined

In this group there were thirty-nine traced cases with six failures, or 15 per cent. There were three cases of fracture in the upper third, with no failures; nineteen in the middle third, with four failures; and seventeen in the lower third, with two failures. (See Table VII.) It is difficult to evaluate percentages fairly in this group, because if one bone united and the other did not, we classified the result as a failure. Also, the bones were occasionally operated on separately several months apart. According to our figures, fractures in the middle third seem to be the most difficult to deal with.

TABLE VII

UNUNITED FRACTURES OF THE RADIUS AND THE ULNA COMBINED TREATED BY BONE GRAFT (1912–1936)

Site of Fracture	Total Cases	Cases Traced	Results			
			Successful		Failure	
			No.	*Per Cent.*	*No.*	*Per Cent.*
Upper third	3	3	3	100	0	0
Middle third	23	19	15	79	4	21
Lower third	18	17	15	88	2	12
Total	44	39	33	85	6	15

MASSIVE BONE GRAFT

For twenty years or more at The Mayo Clinic we have used in preference to the inlay graft of Albee a type which we designated as the "massive graft", called by Willis Campbell the "onlay graft". It might well be called the "massive onlay graft". In our total of sixty-eight cases of failure, twenty-six grafts were of the massive type, and sixteen were of the inlay type. Since comparatively few inlay grafts have been used, in our experience the percentage of failures is definitely higher with the inlay type. Nine intramedullary grafts were used, and the failures in this group were far too many.

The larger the bone graft (in diameter as well as in length) the better the chance of success. For that reason we have used the term "massive" to drive home that important point. While the large size of the graft is of prime importance, its full benefit will only be attained if broad, firm fixation of the graft against the fragments is provided. Mobility of one end of the graft against the fragment is pretty certain to result in failure of the graft to unite to that fragment. It is needless to emphasize the point that the graft must be long enough to extend well onto the sound healthy bone of each fragment.

SELECTION OF CASES

Two factors have a bearing on this question: (1) the general condition of the patient, and (2) the local condition at the site of fracture.

The further below puberty the patient's age is, the greater the chance of failure in bone-grafting operations for ununited fractures. In cases of congenital ununited fractures of the tibia in which several operations have failed, it is usually wise to carry the patients on beyond puberty before any further attempt is made, maintaining length and line as nearly as possible by the aid of braces. Our experience with bone grafts from other individuals, even though the blood grouping is satisfactory, has not been a happy one, although we have had a few successes. Elderly people are good subjects in so far as the bone-grafting itself is concerned, for fractures heal just as readily in the aged as in the young adult. Old people, however, do not stand the loss of blood as well as young adults and every means should be taken to keep bleeding at a minimum; nor will elderly people stand prolonged procedures, so operations should be planned in detail and executed as expeditiously as possible.

Scar tissue at the site of fracture should be avoided whenever possible by making the incision in sound skin. As has been said, all redness, soreness, and local heat should have been absent for many months (six at least and preferably a year) in those cases in which infection has previously existed.

OPERATIVE TECHNIQUE

As a result of our twenty-five years' experience in treating ununited fractures by bone grafts, there has gradually been evolved a technique

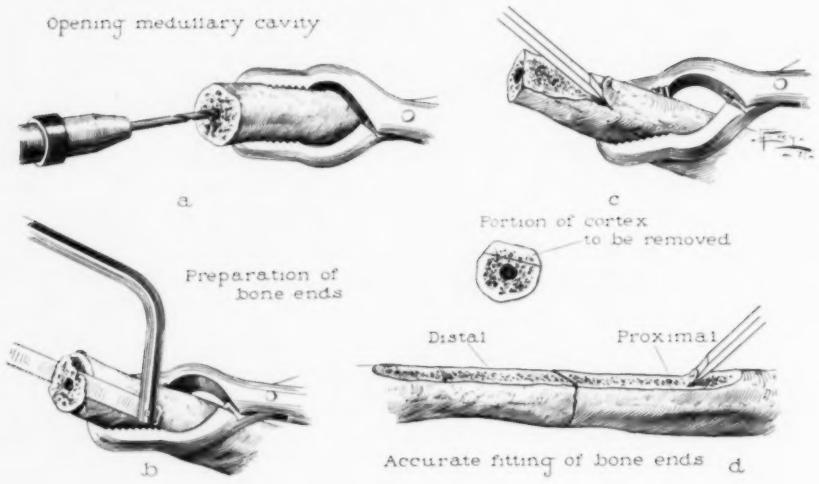

FIG. 1

Preparation of fragments for massive graft: *a*, opening medullary canal with drill; *b*, preparing end of fragment with saw; *c*, preparing cortex with chisel for graft; and *d*, cortex prepared on each fragment and ends freshened and fitted together.

that is giving us a higher percentage of good results than we have ever obtained before. Briefly, it is as follows:

Anaesthesia

Spinal anaesthesia for fractures in the lower extremity, with the knowledge and the new drugs now at the command of skilled anaesthetists, is well-nigh ideal. Lacking the services of an anaesthetist skilled in this type of work, the surgeon had better rely on whatever form of anaesthesia he and his anaesthetist are most familiar with.

Brachial block in operations on the upper extremity is so uncertain that it is rarely used at The Mayo Clinic.

Intravenous anaesthesia is being used more and more at The Clinic. Sodium pentothal, for example, can be given for any operation lasting less than an hour but, because it is a respiratory depressant, it should be given only by those skilled in its use and aware of its potential dangers. Postoperative nausea and discomfort are noticeable by their rarity. Its use is contra-indicated, however, in the case of children under ten years of age and in all cases in which dyspnoea is marked.

Tourniquet

A tourniquet should be used whenever possible, thus assuring a bloodless field. We prefer the pneumatic type for operations on the upper extremity. The incision must be large enough for adequate exposure of the fragments.

Exposure of Bone Ends

In most instances the bone ends must be separated sufficiently to permit dissection of the fibrous tissue from between them; the ends of the bone must be removed and squared off, so that they fit accurately to provide the maximum of contact and still do not shorten the fragments more than is absolutely necessary; and the medullary cavities must be opened. In those cases in which there is no deformity, it may be sufficient to freshen the cortices of the fragments well above and below the fracture site, not disturbing the ends to freshen them or opening the medullary cavity, and to apply a large graft laterally, packing carefully the pieces of spongy bone about the line of fracture.

Preparation of Fragments for Massive Graft

The cortices of the fragments must be carefully prepared for the application of the massive graft, to ensure contact of the graft with fresh viable bone. This is best done with a sharp chisel, gently chipping off the bone until bleeding bone is thus exposed. (See Figure 1.)

Bone Graft

The bone graft should be long and large. We prefer to obtain it from the flat internal surface of the tibia, as high up as possible in the upper third, for this enables us by aid of a large curette to remove many curettefuls of spongy bone from as near the epiphyseal line as possible where the bone is very active in bone-forming properties. (See Figure 2.) The spongy bone and the irregularities on the medullary surface of the bone graft are removed by the aid of bone biters, thus leaving a smooth surface on the graft for coaptation to the freshened, vascular, cortical surfaces of the fragments. (See Figure 3.)

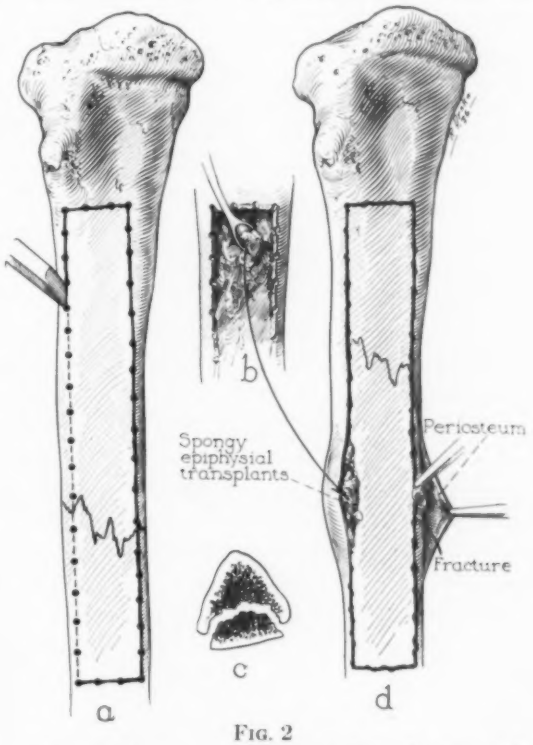

FIG. 2

Bone grafting: *a*, massive graft from flat internal surface of tibia outlined with multiple drill holes and removed by chisel (circular saw on motor may be used, but this is not essential); *b*, spongy bone removed with curette; *c*, cross-section of bone and graft; and *d*, reversible massive graft applicable in tibia; with multiple chips of bone packed about fracture site. (*Courtesy of the Journal of the American Medical Association and of W. B. Saunders Company.*)

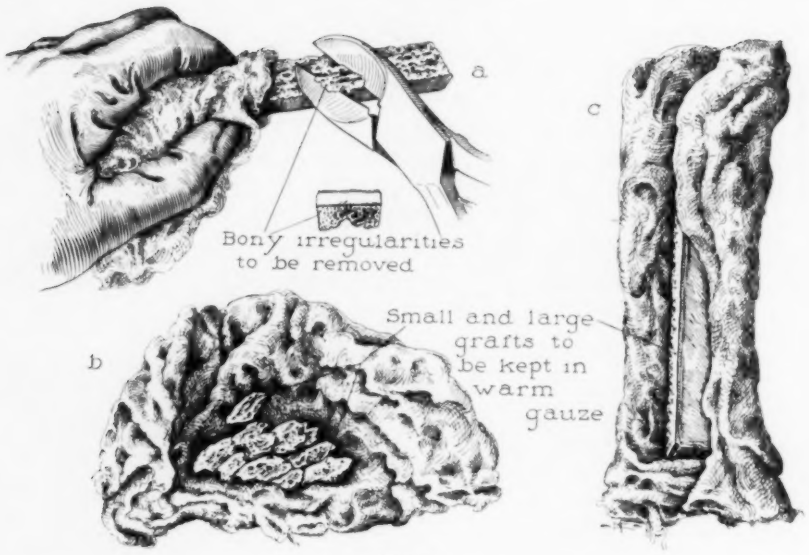

FIG. 3

Bone-grafting: *a*, smoothing down of medullary surface of graft; and *b* and *c*, bone graft and chips of medullary bone kept in moist gauze sponge until time for placing them. (*Courtesy of W. B. Saunders Company.*)

Fixation of Bone Graft

The fragments and graft now being ready, the ends of the bones are pressed securely together and the graft is held with the aid of bone forceps firmly against the prepared cortices, and beef-bone screws, two in each fragment, are inserted. (See Figure 4.) These screws hold firmly, are well tolerated by bone, and do not have to be removed. Autogenous bone pegs may be used, but their preparation is a little tedious and another operating team is really necessary, a condition which only seldom can be fulfilled. In osteoporotic bone, so atrophied and soft that beef-bone screws will not hold, we sometimes use Parham bands to hold the graft tightly to the fragments, but these bands should later be removed.

Bone Chips and Spongy Bone

The massive bone graft thus fastened holds the fragments nicely in position, and the extremity can be moved without motion at the site of fracture. The scrapings of spongy bone removed from near the upper epiphyseal line and the pieces taken from the medullary surface of the graft should be packed carefully about the line of fracture. This is a most important step and one that has decreased very definitely the convalescent period. It adds bone to the area and, furthermore, spongy bone is especially adaptable to transplantation.

EXTERNAL FIXATION

Adequate external postoperative support must be provided. Plaster-of-Paris is ideal; there is nothing to equal it. The support must be con-

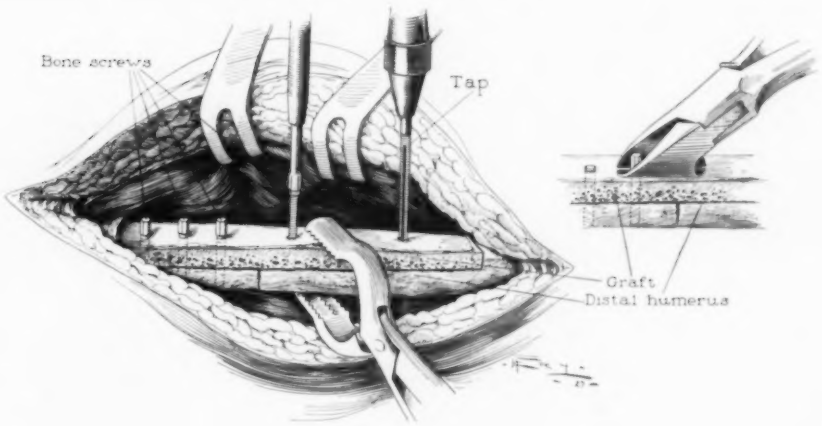

FIG. 4

Fixation of bone graft: The graft is held firmly against surfaces of prepared cortices. Drill holes are made first, then taps are inserted to provide threads in the holes. If this is not done, the beef-bone screws will bind and break when they are screwed in. The hexagonal heads of the bone screws are cut off flush with the graft. (*Courtesy of W. B. Saunders Company.*)

tinued until the fracture is solid. There comes a weak period in any bone graft, about six to eight weeks after insertion, and it is extremely important that external fixation be adequate during that period. Six of our sixty-eight failures were due to disregard of this rule.

BEGINNING OF FUNCTION

No weight-bearing on the lower extremity should be permitted until roentgenograms show bony trabeculations crossing the fracture line. In fractures of the shaft of the femur a walking caliper splint should be worn until bony union is definite. A lift of several inches on the sound shoe and crutches are advisable also. Active movements should be started as soon as it is safe. In the case of fractures in the upper extremity, the time for the institution of movement varies with the individual case; movement must not be permitted until the surgeon is convinced that union has occurred. The entire course must be supervised and controlled by frequent roentgenographic examinations, because this is the one means by which the surgeon can obtain accurate information as to what is going on at the site of fracture.

THE USE OF MULTIPLE SMALL BONE TRANSPLANTS IN THE TREATMENT OF PSEUDARTHROSIS OF THE TIBIA OF CONGENITAL ORIGIN OR FOLLOWING OSTEOTOMY FOR THE CORRECTION OF CONGENITAL DEFORMITY

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From the New York Orthopaedic Dispensary and Hospital

Of all non-unions of bone, those occurring congenitally in the lower tibia or following osteotomy for the correction of congenital deformity in the same region have been the most difficult to repair.

The reasons for this are not clear, as these defects usually differ in no way from those that are sometimes seen following fractures in the adult, or from pseudarthroses occurring occasionally in the course of a spine fusion, or from a non-union in a subtalar arthrodesis for stabilization of a paralytic foot. In each instance, unless there be interposed muscle tissue, the defect consists of fibrous tissue lying between bone ends that show no evidence of reparative growth and that are frequently eburnated. The fragments may be blunt or narrow and tapering with pointed ends. Circulation is at a minimum, and the marrow cavities are often blocked off by dense sclerotic bone. Microscopically, the bone appears dense and often stains irregularly; the fibrous tissue from the defect is well organized, and shows many fibers and flattened cells and sometimes areas of fibrocartilage.

The lower third of the tibia is notorious for the occurrence of non-union. While this is serious enough in the adult, non-union congenitally or in association with the correction of congenital deformity is doubly so. The poor results of treatment in the congenital cases have been universally commented upon, and reported series of cases have not been encouraging.

The subject of non-union, as well as of the growth of bone, has engaged the attention of clinicians and laboratory men for years. According to Murray, from the lack of change in the normal blood-calcium and phosphorus levels in cases with non-union of fractures, from the absence of demonstrable benefit in such cases from treatment designed to affect the body chemistry, and from the fact that fractures heal in the presence of severe disturbances of bone metabolism (as in osteitis fibrosa or Paget's disease), and in the face of negative calcium balances (as in osteomalacia), it would seem that non-union is a local phenomenon, dependent upon local conditions.

Modern ideas of bone growth have been most clearly expressed by Murray, who has stated that in order for bone to form anywhere in the adult body there must be:

1. Death of tissue;
2. Granulation-tissue growth;

3. A local concentration and supply of calcium;
4. A proper quantitative and qualitative status of the blood and lymphatic circulation.

Death of tissue initiates the process of repair. Granulation tissue springs from the traumatized soft parts of the bone—periosteum, endosteum, and the areolar tissue about blood vessels—and from the surrounding soft tissues at the periphery. It is then calcified, possibly as a result of enzyme activity, from a local concentration of calcium probably derived from the injured bone ends by decalcification. The osseous tissue is first laid down in the relatively avascular areas about the blood vessels, and, at a later date, these areas become almost completely replaced by newly formed bone. A proper blood and lymphatic circulation is necessary for this process to proceed normally to completion. It must be not only adequate in volume and rate of flow, but also satisfactory in qualitative properties such as oxygen content, calcium percentage, and hydrogen-ion concentration.

In the transplantation of bone, it has been established, notably by the work of Bancroft and Ely, that the graft dies and serves merely as a local source of calcium and a framework for the growth of reparative tissue and the formation of new bone. The transplant becomes decalcified, and granulation tissue and blood vessels grow into the haversian canals. Calcification and ossification ensue, beginning in the more avascular areas about the blood vessels. This process has been aptly termed "creeping replacement", and in this way the whole graft eventually becomes changed into new bone. The smaller the transplant, the more quickly will its replacement be effected; the larger the graft, the more will its metamorphosis be delayed and the longer will it be in a physically weakened state and subject to fracture. In this fact, lies the weakness of the massive graft and the superiority of the small transplant.

In the past, two methods of repair have been chiefly used in the treatment of any pseudarthrosis,—the open reduction and the massive graft. These measures have often been ineffective, especially in the cases of congenital origin and in patients under the age of twelve. Healing of the pseudarthrosis has not always followed open reduction; and massive grafts, even after union to the fragments, have fractured months later, resulting in a persistence of the original condition of non-union.

When, as in open reduction, sclerosed bone ends are merely exposed and freshened or resected, the prospect for adequate reparative growth of the granulation tissue is poor, because, in only reflecting dense scar tissue and opening into the sclerosed or eburnated bone, relatively few cells are killed and few soft-tissue spaces of the bone are uncovered and traumatized. Cellular elements are distinctly in the minority in this type of tissue. Massive grafts, because of their large size, require many months for complete metamorphosis into new, living bone. They are, therefore, weak and vulnerable to fracture for a long period of time.

To obviate these difficulties and to base practice rationally on modern

conceptions of bone transplantation and growth, the following operative procedure (Figs. 2 and 3) was devised and applied to those pseudarthroses of congenital nature that have always been so difficult to repair.

OPERATIVE TECHNIQUE

The area of pseudarthrosis is exposed by a subperiosteal dissection that should be no more extensive than is necessary, so that circulation to the bone will not be unnecessarily compromised. The bone ends are freshened or resected in sufficient amount to correct existing deformity and are placed in end-to-end contact if possible. A broad, shallow, longitudinal groove is fashioned in both fragments, extending from good bone in the upper fragment to good bone in the lower. This groove opens into the marrow cavities and provides a wide area of traumatized bone for stimulation of granulation-tissue growth and for contact with multiple grafts. The groove is then filled with many small bone transplants or chips taken from the opposite tibia or preferably from the ilium. The periosteum is closed with interrupted sutures so spaced as to leave intervening gaps through which blood vessels and granulation tissue can grow into the area of bone formation from the traumatized soft tissues at the periphery. The wound is sutured in layers. Dressings and a plaster cast are applied. The procedure is best carried out under tourniquet conditions.

Walking in plaster is usually allowed ten or twelve weeks after operation, at which time the cast is first changed. Plaster immobilization is maintained until in the roentgenogram the newly formed bone appears strong enough to function without support.

By this procedure, adequate reparative growth of the granulation tissue is promoted, and the ununited fragments are brought into extensive contact through the medium of many small bone masses which will quickly and readily become decalcified and rehabilitated.

Multiple bone transplants have for years been used in the Hibbs spine-fusion operation to obtain bone growth from one lamina to another. Strong areas of bone formation, which are able to withstand the tremendous deforming forces of corrected lateral curvatures or to hold in check the collapsing vertebrae in Pott's disease, regularly result. Macewen has reported bone growth from bone fragments, and Finney, at Johns Hopkins University School of Medicine, has employed this type of transplantation in ununited fractures of long bones. Bancroft, working in the Department of Surgical Pathology of the College of Physicians and Surgeons, Columbia University, quite regularly obtained excellent healing of experimental defects in the radii of dogs by the use of autogenous small bone transplants.

RESULTS

Five patients have been operated upon by this method at the New York Orthopaedic Dispensary and Hospital from October 1930 to Decem-

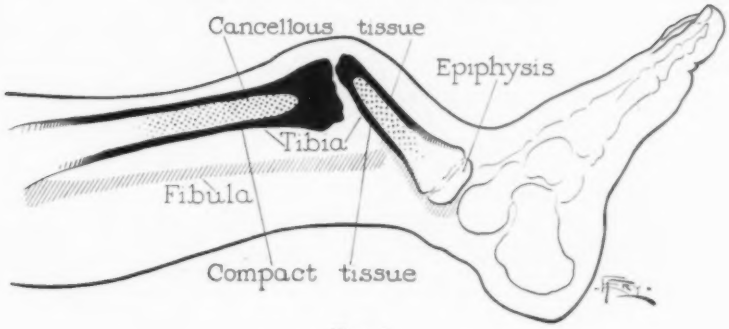

FIG. 1

Drawing showing the preoperative condition.

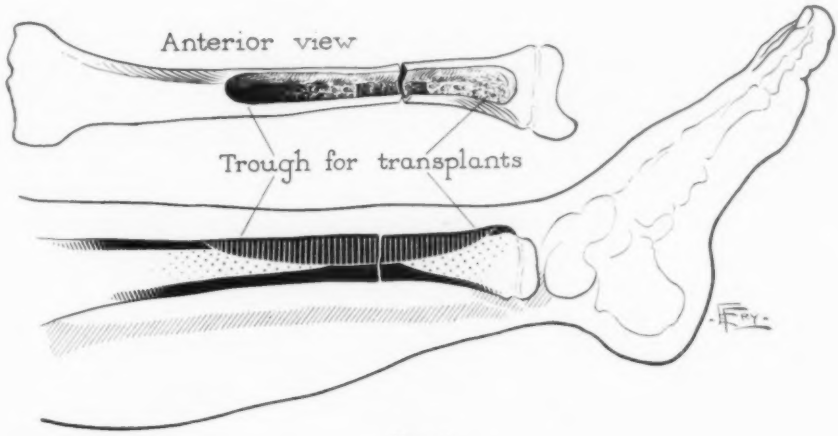

FIG. 2

Drawing showing the technique of the operation. The bones have been resected and aligned. The groove or trough for the multiple small bone transplants extends from good bone proximally to good bone distally.

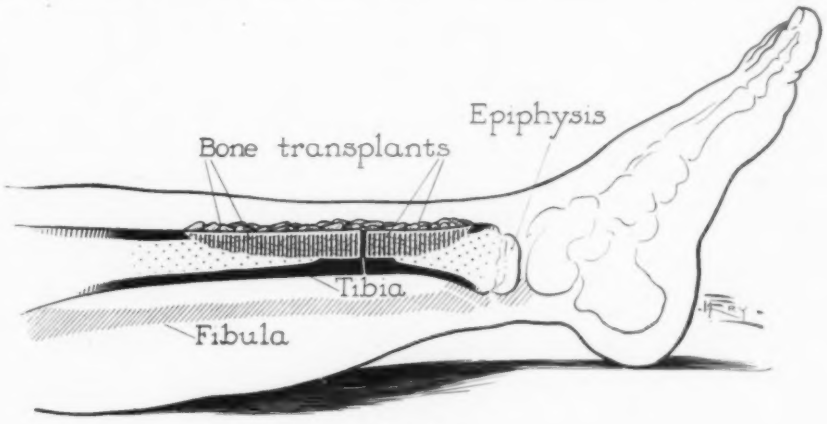

FIG. 3

Drawing showing the technique of the operation. The trough has been filled with numerous small bone transplants obtained either from the ilium or from the tibia.

ber 1935. Three had congenital pseudarthrosis of the tibia; two of these had non-union of the fibula as well. Two had failure of union following osteotomy for the correction of congenital deformity. In one patient, while under convalescent treatment at the Country Branch following operation, a second pseudarthrosis developed just above the first.

Seven primary and four secondary multiple-bone-transplant operations have been performed for seven pseudarthroses. In three of the secondary operations, in addition to the chips, a large graft was used chiefly for immobilization purposes.

Of the seven primary operations, four (57 per cent.) succeeded and three (43 per cent.) failed. In one of the three cases of failure, reoperation by essentially the same method (chips laid along the bone, but without the formation of a groove) was successful. In the second case, reoperation (chips and inlay graft) failed. In the third, implantation of a heterogenous graft and chips from the mother also failed to effect union; this case was complicated by suppuration. The patient in the second case has been operated upon a third time, and successful healing has been obtained. At this operation, a long bone graft was wedged between the longitudinally split and overriding fragments and the interstices were filled with a large number of bone chips. This type of graft procedure was suggested by Dr. William Darrach of the College of Physicians and Surgeons, Columbia University, as a method of massive-graft implantation that would least disturb the circulation of the bone, as the periosteum is not reflected, but is merely split with the bone in the preparation of the bed for the graft.

In the successful cases, strong safe healing with roentgenographically normal appearing bone has been relatively quickly obtained.

CASE REPORTS

CASE 1. G. R., a boy, four and one-half years of age, was admitted to the New York Orthopaedic Dispensary and Hospital on June 17, 1931, for the repair of congenital pseudarthroses of the right tibia and fibula. Two weeks after birth, a swelling had been noticed above the ankle, and a closed reduction was done. Later an open operation had been performed, followed by casts and braces for two years. Non-union had resulted.

The general physical examination was negative. In the lower portion of the right leg there was a 90-degree anterior and a 10-degree lateral angulation of the bones, associated with 10 degrees of motion at the apex. The leg was one and one-half inches short.

Roentgenographic examination revealed a pseudarthrosis of the right tibia at the junction of the middle and lower thirds, with marked anterior and lateral angulation of the fragments. The end of the distal fragment showed condensation, and the proximal fragment was eburnated for a distance of one-half an inch. A similar non-union of the fibula was present in its lower portion.

Repair of the Tibial Pseudarthrosis

The multiple-bone-transplant operation, as previously described, was performed on June 24, 1931. An area of non-union, which permitted several degrees of motion, was found in the lower tibia, associated with marked deformity as indicated in the roentgenogram. The defect was filled with dense fibrous tissue, and the bone ends were extremely hard and eburnated. A similar defect was present in the fibula at a little lower level.

FIG. 4-A

FIG. 4-B

Case 1. G. R., four and one-half years old.
Fig. 4-A: Before multiple-bone-transplant operation on the tibia. The defect in the fibula was repaired seven months later.
Fig. 4-B: Five and one-half years after operation on the tibia and five years after operation on the fibula.

The wound healed well, and there were no complications. The postoperative roentgenograms showed the fragments to be in excellent alignment and the bone ends in contact. Numerous bone chips made good contact with one and one-half inches of the upper and one inch of the lower fragment, and extended above and below into areas of normal appearing bone. Ten weeks after operation, union was present, and a cast for walking was applied. The roentgenogram showed the presence of union through the medium of confluent chips, and beginning union of the bone ends. Plaster support was discontinued at the end of six months, at which time union was firm clinically and roentgenographically.

On January 9, 1937, five and one-half years after operation, union was firm clinically and roentgenographically. The patient walked without a limp. There was one and five-eighths inches of shortening of the right tibia.

Repair of the Fibular Pseudarthrosis

On January 25, 1932, seven months after the operation on the tibia, the fibular pseudarthrosis was similarly repaired. On account of the small size of the upper fragment, it was impossible to make a satisfactory groove; therefore, this fragment was split longitudinally, the edges were held apart, and the intervening space was filled with bone chips which were continued down onto the lower fragment in a groove. Roentgenographic examination, two months after operation, showed excellent bone development from the mass of chips and partial union of the bone ends. Plaster support was discontinued four months after operation, at which time the roentgenogram revealed complete union.

On January 9, 1937, five years after the fibular repair, union was present clinically and roentgenographically.

Case 2. L. C., a girl of nine, was admitted to the New York Orthopaedic Dispensary and Hospital on August 15, 1927, complaining of congenital deformity of the left leg.

On examination, marked anterior bowing of the lower leg was found. The roentgenograms showed a pronounced anterior bowing in the middle and lower thirds of the tibia and an ununited fracture of the lower third of the fibula. On October 31, 1927, the deformity was corrected by an osteotomy. This was followed by non-union, for the repair of which the following unsuccessful operations were performed:

1. Sliding graft and bone chips, March 28, 1928;
2. Open reduction and bone chips, December 13, 1929;
3. Onlay graft and bone chips, February 24, 1930.

The chips used in each instance were small in number and for the most part were placed only about the pseudarthrosis.

The patient was readmitted on October 7, 1930, at the age of twelve. There was a fusiform enlargement of the left tibia at the junction of the middle and lower thirds with motion at this point in all directions. The left leg was two inches short. General physical examination was negative, and the Wassermann test was also negative. In the roentgenogram there was an area of non-union in both the tibia and the fibula. The bone ends were in contact, and the distal fragment of the tibia was deviated medially 20 degrees. Condensation of bone was present in both fragments. This extended for about one inch in the upper fragment and obliterated the medullary cavity for the same distance.

The multiple-bone-transplant operation, as previously described, was performed on October 13, 1930. The graft that had been used at the last previous operation, eight months before, was united at both ends, but through the center there was an area of non-union. This defect was filled with fibrous tissue, and there was no evidence of callus formation. The bone on both sides of the pseudarthrosis appeared to be sclerotic and hypovascular.

Severe shock followed the operation, because of loss of blood. A tourniquet had not

been used at the operative procedure. A transfusion was given, with relief. The wound healed without complication, and the plaster was changed and the skin sutures were removed at the end of two weeks. The postoperative roentgenogram showed the bones to be in good alignment and contact. A large number of small chips made excellent contact across the defect with two inches of the proximal and one and one-half inches of the distal fragment. The ankle was in valgus. The pathological report was "rarifying osteitis with fibrosis". Three months after operation, on January 17, 1931, a cast for walking was applied. No motion was found, and the roentgenogram demonstrated almost complete union. All support was discarded at the end of four months and the roentgenogram revealed complete union.

At follow-up examination on October 1, 1932, two years after operation, the patient had no complaints and no limitation of activity. The left tibia was solidly united, and the ankle and foot were in valgus. Roentgenographic examination showed complete union and almost complete restoration of the marrow cavity.

CASE 3. M. E., a girl, two and one-half years of age, was admitted to the New York Orthopaedic Dispensary and Hospital in April 1930, for the correction of a congenital deformity of the right tibia which was thought to have resulted from a malunion following an intra-uterine fracture. The roentgenogram showed a marked anterior and lateral angulation at the junction of the middle and lower thirds, associated with narrowing of the bone, increased posterior cortical development, and constriction of the medullary canal. The deformity was corrected on July 25, 1930, by osteotomy with multiple linear cuts and greenstick fracture. Non-union occurred. An unsuccessful attempt at repair by open reduction, with bone chips placed at the site of non-union, was done on September 15, 1930. Nineteen months later, the roentgenogram revealed non-union at the junction of the middle and lower thirds in both the right tibia and fibula. The bones were angulated anteriorly 45 degrees. The end of the distal tibial fragment was pointed, but not eburnated. The cortex of the proximal fragment showed increased density for one-half an inch, and the marrow cavity was obliterated for one-quarter and narrowed for three-eighths of an inch.

Operation 1

The multiple-bone-transplant operation, as previously described, and lengthening of the calcaneal tendon, to aid in correction of the deformity, were done on April 9, 1932. The fragments were angulated, and the defect was filled with fibrous tissue. The proximal fragment was narrowed for a distance of one and one-half inches and was eburnated and hypovascular. The marrow cavity terminated three-quarters of an inch from the end. The distal fragment was eburnated for three-eighths of an inch.

Two weeks after operation, the cast was changed and a remaining 20-degree angulation was corrected without force. The postoperative roentgenogram showed the bones to be in contact, but the distal fragment was subluxated medially almost the width of the proximal one. Many bone chips covered two and one-half inches of the shaft above and one and one-half inches below, but appeared scant at the level of the pseudarthrosis.

Two and one-half months after operation, motion was present and the roentgenogram showed non-union. Plaster support was continued, but walking was not allowed. One and one-half months later, the patient was admitted for reoperation.

Operation 2

Multiple onlay bone chips were transplanted on August 9, 1932. No groove was made, and long slender chips were placed closely and with overlapping to bridge both areas of non-union. An oblique pseudarthrosis was found between pointed bone ends, and two inches above there was a second pseudarthrosis traversed by firm fibrous tissue. The bone was covered with moderately vascular scar tissue and possessed a fairly good blood supply; but it was decalcified distally.

The postoperative roentgenogram showed good alignment, but the bone ends were

FIG. 5-A

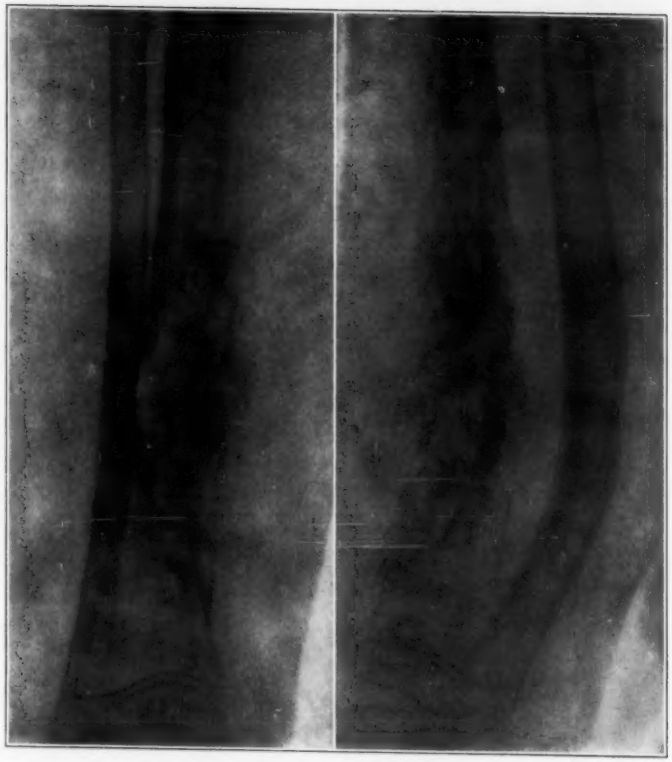

FIG. 5-B

Case 4. M. T., four and one-half years old.
Fig. 5-A: Before multiple-bone-transplant operation.
Fig. 5-B: Immediately after operation. The mass of small bone transplants extends from good bone proximally to good bone distally.

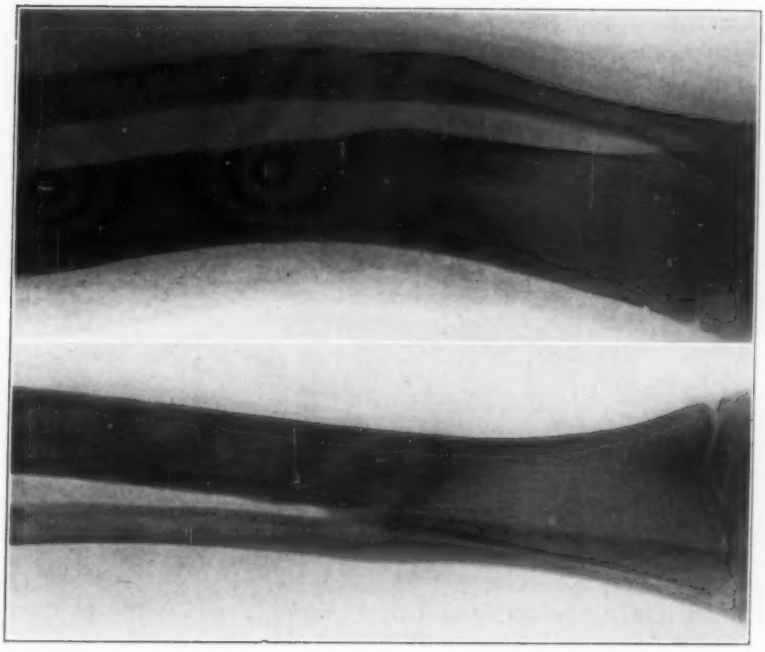

FIG. 5-D

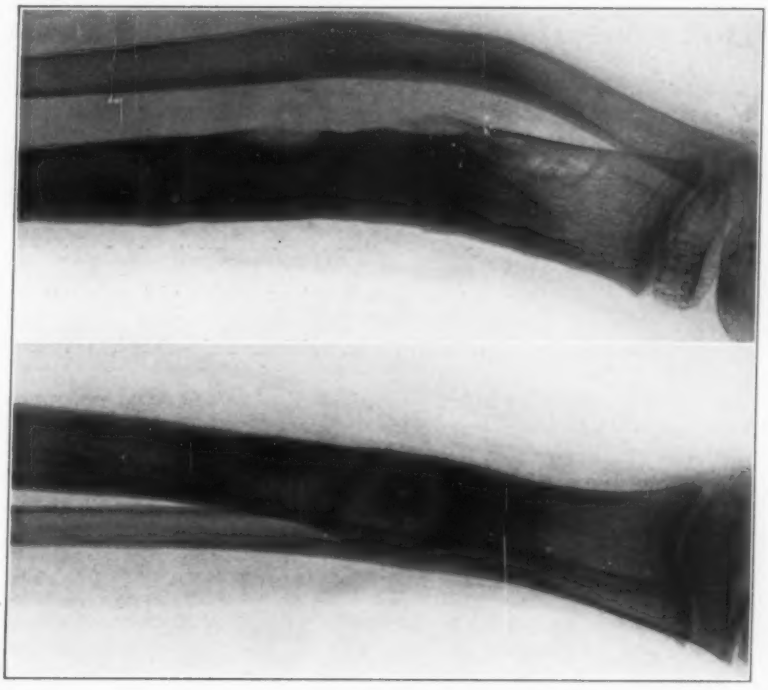

FIG. 5-C

Fig. 5-C: Six months after operation.
Fig. 5-D: Three years after operation. Good union has been obtained.

not quite in contact. A transverse pseudarthrosis was present in the tibia, one inch above the original one. Numerous bone shavings bridged both pseudarthroses, extending one inch above the upper one but not quite into good bone, and three-quarters of an inch below the lower one just to good bone.

The lower pseudarthrosis healed, but the upper one did not, and, on November 14, 1933, fifteen months after the last operation, motion was still present in the lower tibia. The roentgenogram demonstrated failure of union of the upper pseudarthrosis, and good union of the lower and original one, with confluent bone of increased density, but without a medullary canal.

Operation 3

The multiple-bone-transplant operation, as previously described, and transplantation of an inlay bone graft from the opposite tibia were done on December 11, 1933. The periosteum was scarred and adherent about the pseudarthrosis which was filled with a dense scar. The bone was compact, and the marrow cavity ended about one and one-quarter inches from the defect.

The postoperative roentgenogram showed the graft and fragments to be well apposed in good alignment. However, failure of union occurred.

Operation 4

Repair of non-union by open reduction with overriding of fragments, multiple bone chips, and a tibial bone graft, as described in the next paragraph, was done on November 27, 1935. A pseudarthrosis was found at the junction of the middle and lower thirds of the right tibia. Anterior and medial angulation was present with the distal fragment overriding the anterior aspect of the proximal fragment. The ends of the fragments were sclerosed, and the marrow cavity was obliterated about three-fourths of an inch from either end. The defect was filled with tough fibrocartilaginous tissue.

Procedure: The scar tissue in the pseudarthrosis was divided transversely, and the bone ends were freshened. The periosteum was reflected only on the anterior surface of the distal and on the posterior surface of the proximal fragment. Both fragments were then longitudinally split, the cleft reaching high up into normal bone and low down into healthy appearing bone. The fragments were then reduced and the distal fragment was made to override the proximal, but on its posterior aspect. This allowed contact of the most healthy appearing portions of the fragments. The longitudinally divided fragments were then spread apart and a bone graft (five inches by three-eighths of an inch by one-eighth of an inch), cut from the opposite tibia, was inserted in the clefts and sutured in place with 40-day chromic catgut. A large number of bone chips, also taken from the opposite tibia, were distributed throughout the operative area in the bone. The wound was closed in layers, and a plaster cast was applied.

The postoperative roentgenogram showed excellent apposition of the fragments, graft, and chips. Microscopic examination of the tissues removed from the pseudarthrosis showed fibrous, fibrocartilaginous, and bony tissue. Evidence of a little bone formation and bone absorption was seen.

At the end of three months, on February 18, 1936, light union was present roentgenographically, and only a little springy motion was demonstrated clinically. On April 14, 1936, a little less than five months after operation, union was solid, and the patient was allowed to walk in plaster. The cast was removed two months later, and the patient was discharged from the Hospital on August 8. She was last seen in November 1937. Union was present clinically and roentgenographically.

Case 4. M. T., a girl, three and one-half years of age, was admitted to the New York Orthopaedic Dispensary and Hospital on November 24, 1930, for the repair of a non-union of the right tibia, which was first noticed eight days after birth. A closed reduction and then an open reduction were done early in life without success. On December 5, 1930, two onlay grafts were laid across the defect, and bone chips were placed about them. A cast was applied, and the child was kept in bed for three months, and

then allowed to walk with the leg in plaster. Both grafts underwent irregular absorption. One fractured in two places before the end of three months, and the other fractured during the fourth month. Two of these fractures, one in either graft, healed and one did not. Later, another fracture occurred just below a healed one, and non-union was the result.

Thirteen months after operation, at the age of four and one-half years, the patient was readmitted. The right tibia was enlarged in the lower portion, which showed a little anteromedial deviation. Slight motion was present at this point. The leg was one and one-quarter inches short. The general physical examination was negative, and the Wassermann test was also negative. The roentgenogram showed an area of non-union at the junction of the middle and lower thirds, with one inch of eburnated bone in either fragment.

The multiple-bone-transplant operation, as previously described, was performed on January 18, 1932. The bone ends were hard and the distal one was eburnated. The marrow cavity of the proximal fragment extended to within three-quarters of an inch of the line of non-union, and that of the distal to within one-half an inch. Deformity was not marked, the general alignment of the leg was good, and no attempt at correction was made. The defect was filled with fibrous tissue.

No complications developed, except a stitch abscess which healed readily. The plaster was changed and the sutures were removed on the sixteenth day. The postoperative roentgenogram showed multiple bone chips that made excellent contact over a large area from good bone above to good bone below. Microscopic study of material removed at operation showed fibrous tissue and fibrocartilage.

On March 15, 1932, two months after operation, union was present and was corroborated roentgenographically. Walking in a plaster cast was allowed. At the end of four months, all support was discarded, and the roentgenogram showed further progression toward complete union. At the end of six months, union was complete.

On January 5, 1935, three years after operation, union was solid in good alignment. The patient walked well and had no limp or pain. Measurements revealed one inch of shortening in the right leg.

CASE 5. M. P., a colored girl, aged three, was admitted to the New York Orthopaedic Dispensary and Hospital on January 7, 1933, for repair of a congenital pseudarthrosis of the left tibia and fibula. She had had no previous treatment except for rickets. A false point of motion and a marked anterior angulation in the lower leg were noted. Measurements were not recorded, as it was impossible to obtain accurate ones because of the marked deformity. The roentgenogram showed an area of non-union at the junction of the middle and lower thirds of both the left tibia and fibula, with a 90-degree anterior angulation. The tibial fragments were tapering and narrow. The distal tibial fragment and both fibular fragments were eburnated.

Operation 1

Lengthening of the calcaneal tendon was done on January 23, 1933. The deformity was corrected to a 65-degree angulation.

Operation 2

The multiple-bone-transplant operation, as previously described, was performed on February 21, 1933. A 90-degree anterior angulation with pseudarthrosis was found. The bone ends were separated one-eighth of an inch by dense fibrous tissue and were eburnated and avascular for a distance of one-quarter of an inch. A similar narrow pseudarthrosis was found in the fibula.

The wound healed well, and there were no complications. Microscopic study of tissue removed at operation showed cellular connective tissue, absence of bone formation, and poorly staining but relatively normal bone. The postoperative roentgenogram revealed a gap of three-eighths of an inch between the tibial fragments. Numerous small bone chips, scant at the line of pseudarthrosis, made good contact with the tibial frag-

ments for one inch above and three-quarters of an inch below the line of non-union, and extended well into good bone.

Two and one-half months after operation the plaster was removed. Motion was present, and the roentgenogram showed that all the bone chips had disappeared, except for a group at the proximal fragment, which had formed a mass of bone, attached to the shaft. There was a gap of three-eighths of an inch and the distal fragment had become posteriorly displaced upon the upper one.

On June 16, 1933, four months after operation, the fibrous tissue was removed from between the bone ends, and the eburnated bone was resected. An onlay graft was taken from the mother's tibia and was laid across the defect in the patient's tibia. The space between the bone ends was filled with chips also from the mother's tibia. Infection developed, sequestration of the graft occurred, and non-union resulted. The leg is at present (1937) in a brace, and repair will be attempted when the child is older.

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MYOSITIS OSSIFICANS

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The clinical and pathological data on twenty-five cases of myositis ossificans collected in the Surgical Pathological Laboratory of the Johns Hopkins Hospital and University are reviewed in this paper. The series includes both the circumscribed and the progressive forms.

The circumscribed form has been subdivided into several types by various authors, but we are inclined to accept only the clinical varieties of traumatic and non-traumatic myositis ossificans. Trauma is the most common cause of muscle ossification. Fifteen cases, or 60 per cent., of the present series had a definite history of injury. The lesion may follow a single mild or severe blow. Dislocations or fracture-dislocations, especially of the elbow, may give rise to these pathological changes. This series included one instance of fracture, but no dislocations. In the older literature, ossification is often described as occurring in the thigh muscles of shoemakers, or in the "rifle shoulders" of infantry men, or in the thighs of cavalry men (so-called "rider's bone"). Occupation played no rôle in any case of this series. The thigh was involved in fourteen instances; the arm, in three; the elbow, in two; the neck and the lumbar muscles, once each. The age of onset varied from thirteen to seventy-two years. Sex appeared to be an outstanding factor and is probably explainable on the basis of activity. In a series of twenty-three cases, there were twenty-one males, one instance in which the sex was unrecorded, and only one female.

Although many cases of myositis ossificans progressiva have been collected in the literature, only two were found in the series of twenty-five cases of muscle ossification. This form, which was first described by Guy Patin in 1692, usually begins in childhood and has a predilection for the muscles of the spine. As the name implies, it is progressive and eventually involves the muscles of the entire skeletal system. Trauma plays an important etiological rôle, but, as is the case with the circumscribed type, the cause is unknown. Both of our cases occurred in females. The first followed a fall at the age of six, and began in the muscles of the neck. The second case, also resulting from an injury, began at the age of ten; the first lesion was in the muscles of the thoracic portion of the spine. In both cases the lesions slowly progressed and became multiple.

The earliest physical finding consists of a doughy mass which gradually becomes indurated. It may make its appearance within a few hours. The earliest evidence of ossification is manifested in the roentgenogram by small, discrete, dense shadows which lie some distance from normal

FIG. 1

Early x-ray changes in a case of myositis ossificans, showing dense discrete shadows.

bone (Fig. 1). These areas gradually become confluent and form one large spicule of bone that continues to be separated from the shaft in about three-fifths of the instances (Cahier). Bone can be seen roentgenographically as early as three weeks, and it reaches its maximum growth in from ten weeks to six months (Gruca). Lewis states that bone formation ends within six weeks, and then either regresses or remains stationary. Kienböck, in a roentgenological description of the condition, specifies four weeks as a minimum time in which bone can be detected by x-ray. Bone has been found in abdominal wounds as early as three weeks. One of our recent cases showed calcification of the thigh muscles within nineteen days. The roentgenographic appearance varies. Beginning as the small dense shadows already described, the ossification may assume large proportions and various shapes. The so-called "dotted-veil" appearance seen in the roentgenogram (Fig. 2) has been described by one of the authors as pathognomonic.

The diagnosis is not always simple. Malignancy can often be eliminated only with difficulty. Malignant changes may complicate a benign lesion (Chambers, Coley, Paul). In one instance, myositis ossificans followed operative removal of an exostosis and simulated the cartilaginous cap usually found surmounting an exostosis (Fig. 3). Periosteal ossification resulting from various causes can be eliminated with careful consideration.

PATHOLOGY

The bone lesion, when exposed at the operating table, is usually surrounded by a gelatinous substance which appears to be the result of muscle degeneration, and the lesion is intimately related to this tissue. Since the bone is often attached to the shaft, it follows that the gelatinous material is then absent in part. Beneath this material a fibrous capsule is usually found, and it is apparently this capsule which is the mother substance of the bone formed in myositis ossificans. Radiating from the capsule are irregularly distributed bands of connective tissue which also invade the bone formation. Cystic changes are occasionally found

FIG. 2

The so-called "dotted-veil" appearance in an advanced case of myositis ossificans. (*Courtesy of The American Journal of Cancer.*)

FIG. 3

A case of myositis ossificans secondary to operative removal of an exostosis, in which muscle ossification simulated the cartilaginous cap ordinarily found surmounting the spicule.

(Schultz and others). This series includes one case that presented cystic changes and grossly resembled a giant-cell tumor (Fig. 4).

HISTOLOGY

In a study of twenty-five cases, the presence of hemorrhage, the organization of hemorrhage, cartilage, endochondral ossification, periosteal ossification, myxomatous tissue, angiomatous tissue, calcification *en masse*, hyalinization of capillaries, and degeneration of muscles were found. Any group of these may accompany bone formation in a section or group of sections. The authors were impressed by the predominance of a

FIG. 4

A gross specimen of myositis ossificans, presenting cystic changes.

TABLE I

SUMMARY OF CASES OF MYOSITIS OSSIFICANS

Pathology No.	Age (*Years*)	Race	Sex	History	Physical Examination	Diagnosis
37312	13	White	Male	Injured thigh falling off bicycle	Mass in thigh	Myositis ossificans traumatica
26712		White	Male	Specimen of tissue from an amputated leg sent to this laboratory	Mass in thigh following football injury	Original diagnosis: sarcoma Final diagnosis by our laboratory: myositis ossificans traumatica
10249	15					Myositis ossificans
36200	36	White	Male	Injured thigh	Mass in thigh	Myositis ossificans traumatica
56333	25	White	Female	Progressive swellings beginning at age of six	Multiple areas of ossification	Myositis ossificans progressiva
22323	43	White	Male	Struck in thigh by flying wheel	Mass in thigh	Myositis ossificans traumatica
43038	19	Colored	Male	Injured thigh playing football	Mass in thigh	Myositis ossificans traumatica
37966	27	White	Male	Recurring attacks of pain in right knee beginning at age of sixteen	Mass in right thigh	Myositis ossificans circumscripta
18584		White	Male	Specimen submitted to this laboratory History indefinite		Myositis ossificans
44802	72	White	Female	Slowly growing mass in neck of one year's duration	Nodular mass in neck	Myositis ossificans?
48662	11	White	Male	Fractured elbow	Mass in anterior and internal portions of elbow	Myositis ossificans traumatica
322	30	White	Male	Injury	Swelling in right thigh	Myositis ossificans traumatica

TABLE I (*Continued*)

Pathology No.	Age (*Years*)	Race	Sex	History	Physical Examination	Diagnosis
56331	10	White	Female	Injury	Multiple areas of ossification	Myositis ossificans progressiva
43672	25	White	Male	History of injury	Mass in thigh	Myositis ossificans traumatica
36014	28	White	Male	Lump in arm, several weeks following sprain of shoulder	Mass in arm above insertion of deltoid muscle	Sarcoma secondary to myositis ossificans traumatica
31538	20	White	Male	Injured arm playing football	Mass in arm	Myositis ossificans traumatica
33534	17	White	Male	Injured thigh Noticed tremor several weeks later	Mass in thigh	Myositis ossificans traumatica
36016		White	Male	Swelling in leg following injury	Mass in thigh	Myositis ossificans traumatica
8640	18	White	Male	Dull pain in lumbar region Noticed lump a month later	Mass in lumbar region	Myositis ossificans circumscripta
10961		White	Male	Injury eight weeks previously	Mass in thigh	Myositis ossificans traumatica
6461	30	White	Male	Injured arm falling through hatch	Mass in anterior cubital fossa	Myositis ossificans traumatica
53128	46	White	Male	No injury Pain in both thighs, subsiding in one	Mass arising in one thigh	Myositis ossificans circumscripta
11343	28	White	Male		Mass in biceps	Myositis ossificans
58176	18	White	Male	Exostosis of femur removed X-ray three months postoperatively showed a myositis ossificans complicating a recurring exostosis	Mass in vastus medialis	Myositis ossificans traumatica
59228	13	White	Male	Trauma eight weeks previously	Mass in right thigh	Myositis ossificans traumatica

TABLE II

CLASSIFICATION OF MUSCLE OSSIFICATION BY TISSUE CHANGES

Changes	No. of Cases
Typical	15
Cartilaginous	5
Angiomatous	2
Myxomatous	2
Malignant	1
Total	25

FIG. 5

Photomicrograph (medium magnification), showing young osteoid tissue surrounded by osteoblasts.

single type of change in a given instance. The cases studied could be grouped by these secondary changes which, with the exception of malignancy, are not dependent upon the types of ossification and vary with the section and stage of ossification. (See Table II.) Although the classification has no apparent clinical value, it is of assistance in the study of muscle ossification.

Degeneration of muscles, hyperplasia of connective tissue, and organization of hemorrhage are the earliest histological manifestations. There

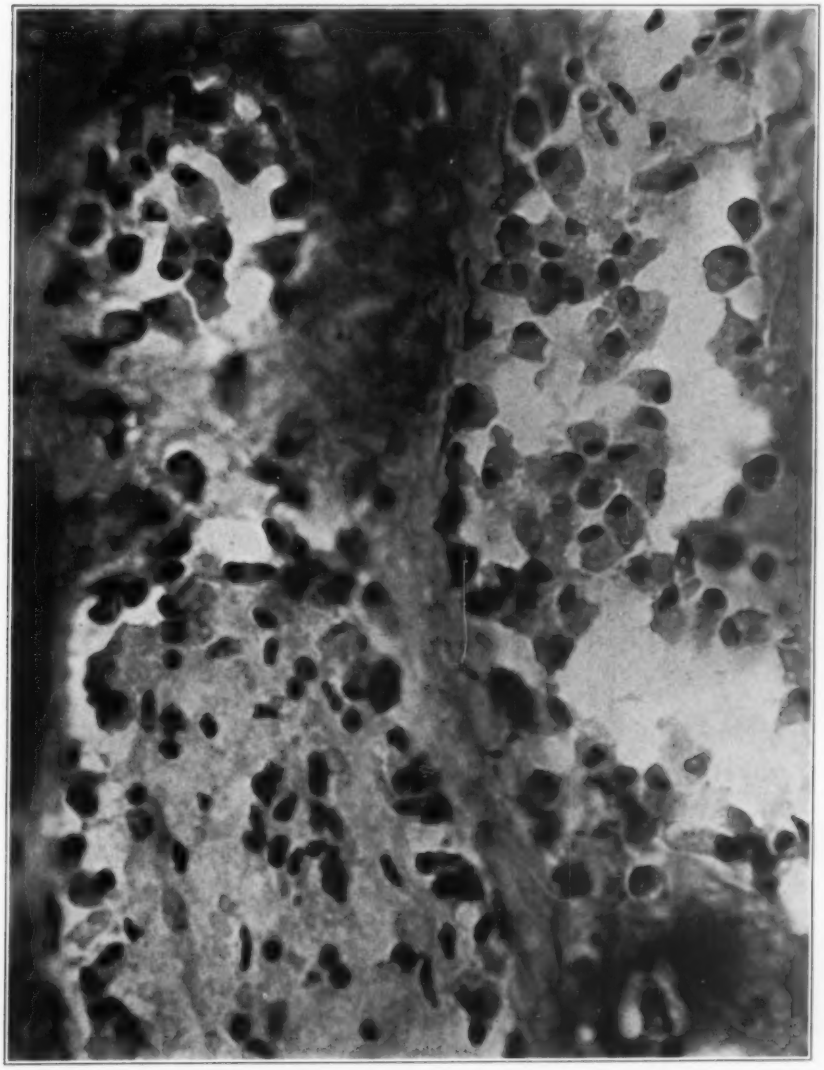

FIG. 6

Photomicrograph (medium magnification), showing collections of colloid material which appears to be a nucleus for bone-spicule formation.

FIG. 7

Photomicrograph (medium magnification) of cartilage in myositis ossificans.

appears to be a tendency to capsule formation, which is almost simultaneous with calcification *en masse* of the inner portion of young connective tissue. Islands of osteoid tissue (Fig. 5) spring up and become invaded and surrounded by osteoblasts. Marrow spaces form, and capillary slits, filled with numerous red cells, appear. Aggregations of small collections of colloidlike material, probably osteomucin, were seen in a few specimens, and they appeared to form a nucleus for future bone spicules (Fig. 6). With advancing bone formation, partially formed osteoid

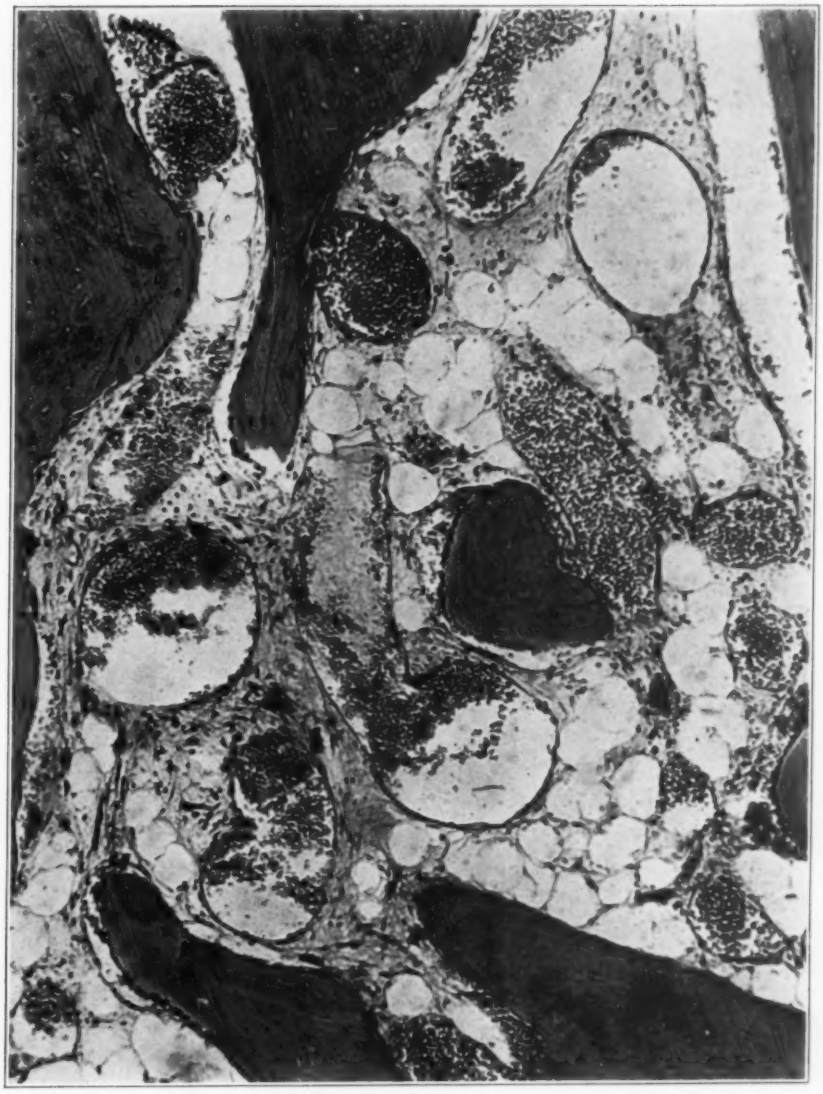

FIG. 8

Photomicrograph (medium magnification) of bone formation within capillary walls.

spicules are surrounded by numerous osteoblasts. The more completely formed spicules are typical of those seen in the complete process of normal cancellous-bone formation and are surrounded by well-formed osteoblasts with nuclei for the most part eccentrically placed.

The presence of cartilage in ossifying myositis has often been reported. In the pathological material under consideration, cartilage occurred in from 25 to 30 per cent. of the total. Pseudocartilaginous areas are occasionally found, and one then hesitates to accept the presence of

true cartilaginous tissue. Cartilage can be definitely distinguished in about one-fourth of the instances. The rôle played by this tissue in bone production is probably the same as in endochondral ossification and is comparable to areas of cartilage adjoining bone in osteochondromata. (See Figure 7.)

Occasionally numerous fairly large capillaries make up an extensive portion of the sections and appear to be foci destined for bone formation. These capillaries are round, oval, or often shaped like their neighboring developed bone spicules. The contents consist of red blood cells that may

FIG. 9

Photomicrograph (medium magnification) of myxomatous tissue between bone spicules.

have undergone hyalinization, and then exist as homogeneous masses lying free and retracted from the endothelium-lined lumina of the capillary walls. Some capillaries present beginning organization of the cellular contents, while others are almost completely formed bone spicules with osteoblasts surrounding their borders. One can apparently trace the formation of a bone spicule within a blood capillary, but it is difficult to venture an opinion concerning the exact order of the process by which bone is formed. Osteoblastic invasion and calcification are the probable

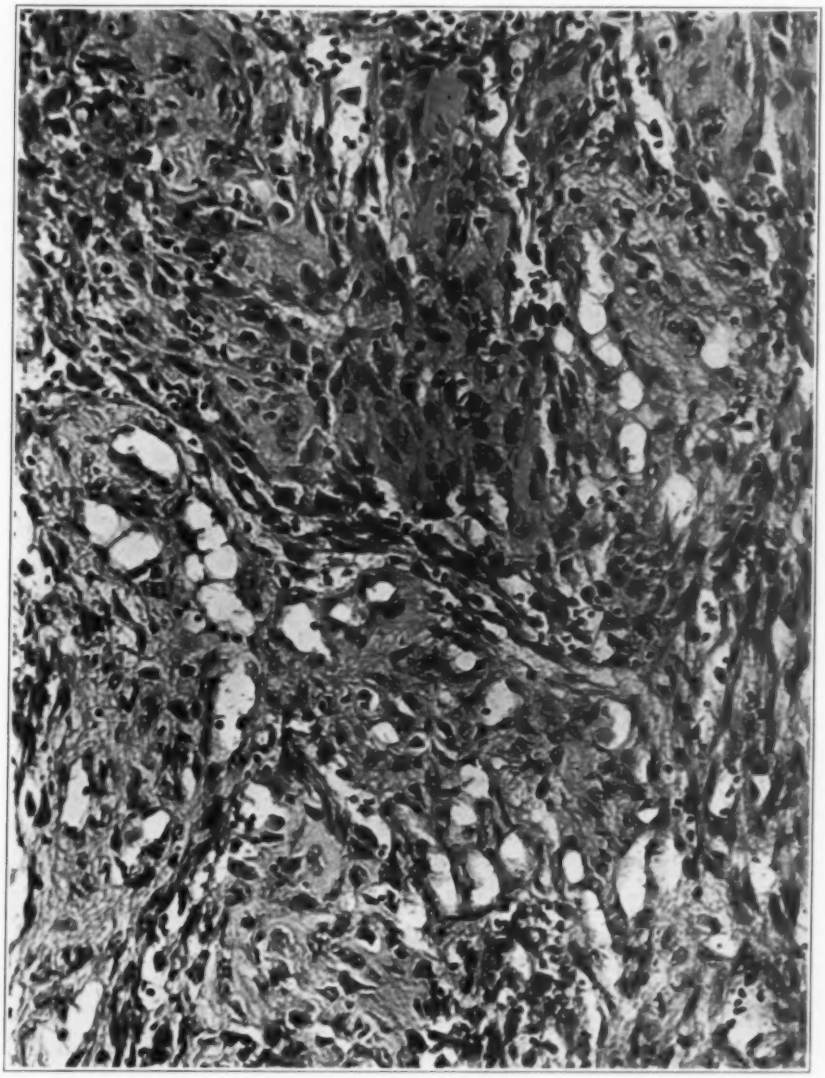

FIG. 10

Photomicrograph (medium magnification) of pseudomalignant tissue in myositis ossificans.

FIG. 11

Photomicrograph (medium magnification) of tissue from second operation in a case of malignancy complicating myositis ossificans. The area is suggestive of fibrosarcoma.

changes which precede bone formation. (See Figure 8.) Moschcowitz minutely described similar changes of ossification in the ovary, but his explanations are not wholly in accord with the authors' views.

Myxomatouslike tissue is not uncommon in between the bone spicules, but this tissue is definitely benign. (See Figure 9.) There were two instances, however, in which the tissue simulated malignancy and the clinical evidence definitely pointed to benignity. In one, the stroma cells were abundant and suspicious-looking, consisting of various forms,—often spindle-shaped and lamellated. There were areas of malignant-appearing osteoblasts attempting to form bone in an osteoidlike stroma, creating

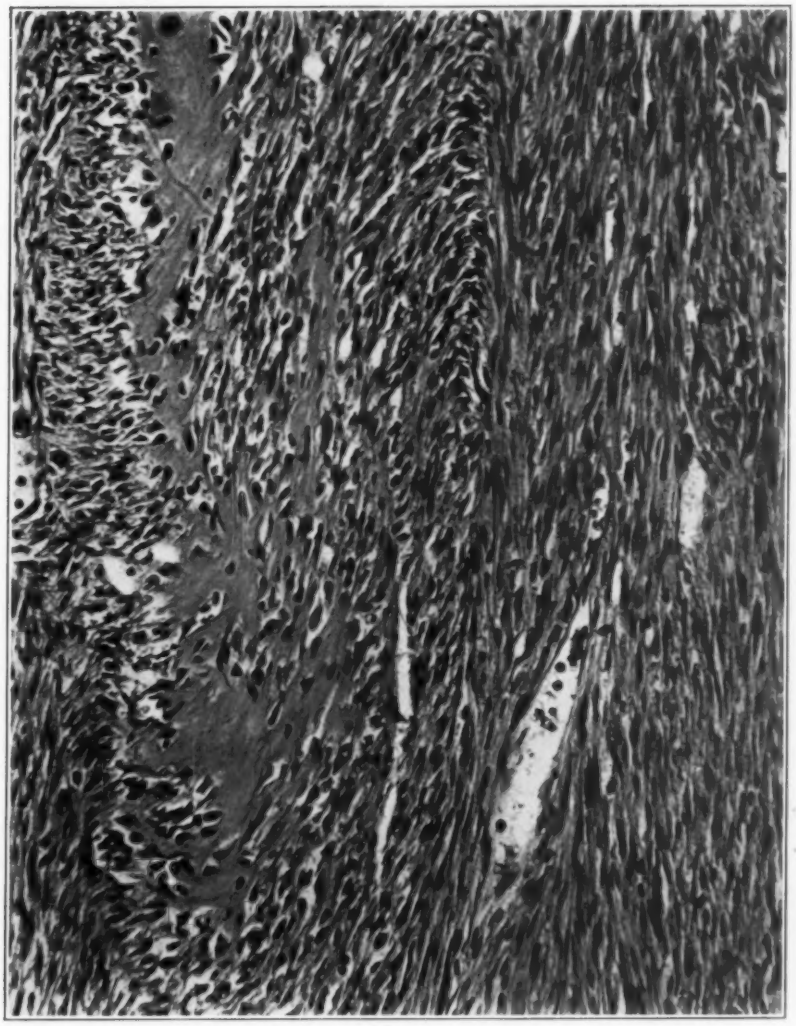

FIG. 12

Photomicrograph (medium magnification) of tissue from a metastatic nodule in the lung. Osteoid tissue in a fibrosarcomatous tissue.

the appearance of an osteogenic sarcoma. In the second instance, a myxomatouslike tissue, containing cartilage, was noted. The tissue cells and arrangements were very suggestive of chondromyxosarcoma. (See Figure 10.) Since the treatment in both cases was conservative and the results were good, one may conclude that the presence of this tissue in muscle ossification is of no true significance.

There was one instance of malignancy complicating a case of myositis ossificans traumatica. The tissue taken at the first operation was unquestionably benign. The section removed at the second operation presented areas suggestive of fibrosarcoma. (See Figure 11.) The lung

tissue removed at autopsy was replaced by a very cellular stroma with marked tendency to whorl formation. Within the meshes of this tissue were occasional spicules of bone. (See Figure 12.)

TREATMENT

The analysis of these cases led us to believe that the conservative form of treatment is often preferable to the radical form. Post-operative recurrences are common, especially if surgical removal of the tumor is undertaken before six months, or if resection is not complete. Deep x-ray therapy is being tried in a series of cases. We are unable at this time to evaluate its usage. It must be remembered that ossification occasionally regresses and, when persisting, is not always a functional or painful disturbance.

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THE DIAGNOSIS AND TREATMENT OF SACRO-ILIAC CONDITIONS BY THE INJECTION OF PROCAINE (NOVOCAIN)

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The confusion which exists among physicians in regard to the diagnosis of and the pathological changes in various conditions attributed to the sacro-iliac joints indicates the need for a more exact diagnostic procedure than is now in common use. Often derangements of the lumbosacral articulations, true sciatic neuritis, or intraspinal lesions are difficult to distinguish from the true sacro-iliac syndrome, because of their somewhat similar neurological and postural manifestations. Although each of these conditions has distinguishing clinical patterns, exact diagnosis is often lacking, and one must resort to radical therapeutic measures without the certainty that benefit will follow. Therapeutic tests, such as traction and body casts, are also helpful, but they are time-consuming and troublesome to the patient. For these reasons, we offer the following routine as an aid in the diagnosis and treatment of conditions attributed to derangement of the sacro-iliac joints.

During the past decade considerable work has been reported on the use of procaine hydrochloride in the treatment of disturbances of various joints. This method of treating sprains of the ankle and of other joints was popularized by Leriche. The value of injections of procaine in the diagnosis and treatment of lesions in the shoulder region has been reported by the authors. In cases of painful coccyx, Mandl obtained a favorable response to the epidural injection of procaine through the sacral hiatus. The method of injection of procaine into the sacro-iliac joint, which forms the basis for the present report, was described by one of us (K. O. H.) in 1936. A somewhat similar procedure in the treatment of backache centering at the thoracolumbar junction was recently discussed by Judovich and Bates. The results of a very painstaking analysis of the differential diagnosis in low-back pain, by means of the injection of a few cubic centimeters of procaine into the tender point in the lower back, were presented by Steindler and Luck before the American Medical Association in June 1937. They did not use this injection for the purpose of treatment, but, rather, to determine the relationship of referred sciatic pain to the tender area in the lower back.

The series presented in this paper consists of forty-two consecutive cases in which a diagnosis of probable chronic sacro-iliac strain had been made. Twenty-four patients in this group also complained of pain along the course of one or of both sciatic nerves. We excluded from this study

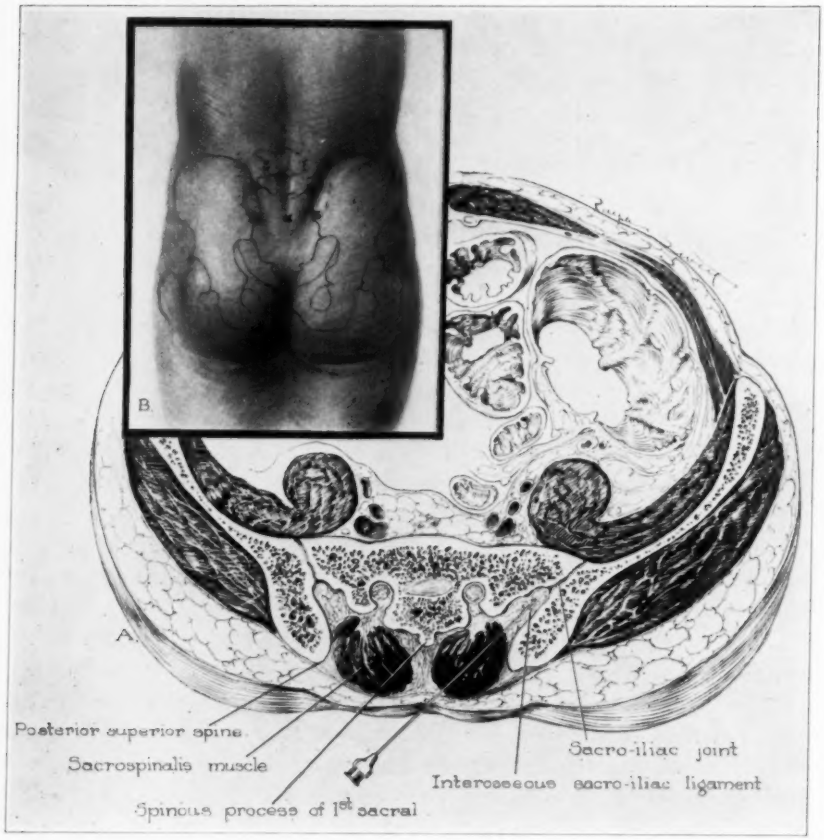

FIG. 1

patients with acute sacro-iliac injuries, although we used this procedure with some benefit in such cases. The first few patients were treated with simple injection, and some improvement was noted. Because of the marked relaxation that occurred after injection, with disappearance of muscle spasm, list, and pain on the straight-leg-raising test, we added the routine use of manipulation of the sacro-iliac joints.

METHOD

The method of injection and the routine of manipulation are as follows: The patient is placed in the prone position on a table and the sacral region is prepared. It is our practice to administer orally three grains of sodium amytal at this time to prevent any possible reaction from the procaine. About twenty to thirty cubic centimeters of 1-per-cent. procaine is injected. In cases of bilateral sacro-iliac strain, fifteen or twenty cubic centimeters of the solution may be injected into each side. Anatomical studies have shown us that the best approach to the sacro-iliac joint requires the insertion of a long (spinal-puncture) needle at a point over the sacrum midway between the two posterior superior spines

of the ilia. (See Figure 1.) The needle is then directed toward the desired side, so as to make an angle of 45 degrees with the skin. At this angle, the needle will pass between the lateral portion of the sacrum and the overhanging posterior superior iliac spine, through the fibers of the interosseous sacro-iliac ligament to the posterior margin of the sacro-iliac joint. The procaine is slowly injected while the needle is being inserted. After encountering bony resistance, the needle is partially withdrawn and reinserted several times, so as to obtain a fan-shaped area of infiltration along the posterior aspect of the sacro-iliac joint. A word of caution seems advisable: The needle should not be inserted at such an angle that it will pass superiorly to the upper margin of the sacrum, as it might cause damage in this region. This approach to the sacro-iliac joint becomes apparent if one studies a mounted skeleton. After waiting five or ten minutes for local anaesthesia to take place, the examiner carries out the manipulation of the sacro-iliac joints. Such manipulations include straight-leg raising, hyperextension of the hip with the knee flexed and the patient in the prone position, sudden traction on one leg while the other is fixed, and the method whereby one shoulder is pressed against the table and the pelvis on the same side is rotated forward as far as possible, the patient being in the supine position. It is usually found that straight-leg raising, which is limited and painful before injection, becomes normal or much improved under local anaesthesia. Likewise the patient can flex the spine forward much farther after the injection. The lower back is then strapped with adhesive tape, and the patient is instructed to report in a few days. In a few cases there was an exacerbation of sciatic pain for a day or two following the manipulation, and an analgesic was required. In a few instances in which relief was transitory, the injection of procaine was repeated after one week, usually with additional improvement.

RESULTS

The records of forty-two patients here reported were studied and tabulated as to symptoms, signs, roentgenographic findings, treatment, and results. These tables were condensed for publication, with special attention to the results of the injection of procaine (Table I), and the tabulation was further condensed to show end results (Table II). It is unfortunate that a final examination could not have been recorded for every patient, but many of them were seen in a clinic and the records were incomplete.

DISCUSSION

From the results obtained in this series of cases, it would appear that the local injection of procaine in patients presenting the clinical picture of chronic sacro-iliac derangement causes an immediate transient disappearance of signs and symptoms in most of these cases, and, in a fairly large proportion of instances, the relief obtained is more lasting. The immediate improvement in symptoms we attribute to the injection itself. In the large majority of cases in which manipulation also was used, the

TABLE I

RESULTS OF INJECTION OF PROCAINE INTO SACRO-ILIAC JOINT

Case No.	Location of Pain	Clinical Diagnosis	Injection of 1-Per-Cent. Procaine	Immediate Results		Late Results	
				Objective	Subjective	Objective	Subjective
1	Left sacro-iliac joint	Chronic left sacro-iliac strain	20 c.c. in left sacro-iliac joint	Flexion* improved (12 inches to 6 inches) Straight-leg raising normal	Progressive improvement	No relapse in 4 months	No relapse in 4 months
2	Left sacro-iliac joint and left sciatic nerve	Left sacro-iliac strain with sciatic pain	10 c.c. in left sacro-iliac joint	Flexion improved Straight-leg raising improved	Pain disappeared		No pain 2 days later
3	Left sacro-iliac joint and left sciatic nerve	Left sacro-iliac strain with sciatic pain	15 c.c. in left sacro-iliac joint	Flexion improved (6 inches to 0) Straight-leg raising improved (50 degrees to 80 degrees)	Immediate improvement	No permanent relief; cured by sacro-iliac fusion	
4	Both sacro-iliac joints	Bilateral sacro-iliac strain	10 c.c. in each sacro-iliac joint	Flexion improved (20 inches to 10 inches) Straight-leg raising improved on both sides	Increased pain, then gradual improvement	Permanent improvement	No relapse in 10 months
5	Right sacro-iliac joint and right sciatic nerve	Right sacro-iliac strain with sciatic pain	25 c.c. in right sacro-iliac joint	Flexion improved (8 inches to 4 inches) Straight-leg raising improved (70 degrees to 90 degrees)	Slow progressive improvement	Permanent improvement	No relapse in 2 years
6	Right gluteal and right sciatic nerves	Right sacro-iliac strain with sciatic pain	20 c.c. in right sacro-iliac joint	Flexion improved (8 inches to 0) Straight-leg raising improved (60 degrees to 90 degrees)	Increased pain, then gradual improvement	Permanent improvement	No relapse in 1½ years

*Flexion = distance in inches by which fingers fail to touch floor in forward flexion.

TABLE I (*Continued*)

RESULTS OF INJECTION OF PROCAINE INTO SACRO-ILIAC JOINT

Case No.	Location of Pain	Clinical Diagnosis	Injection of 1-Per-Cent. Procaine	Immediate Results		Late Results	
				Objective	Subjective	Objective	Subjective
7	Right sciatic nerve	? Right sacro-iliac strain (thickened ligamentum flavum)	20 c.c. in right sacro-iliac joint	Flexion* improved (9 inches to 5 inches) Straight-leg raising improved (60 degrees to 80 degrees)	Transient improvement	Improved after 10 months	Relapse of pain after 1 month
8	Right sacro-iliac joint and right sciatic nerve	? Right sacro-iliac strain (protruded fourth lumbar disc)	20 c.c. in right sacro-iliac joint repeated	Flexion improved (15 inches to 8 inches) Straight-leg raising improved (50 degrees to 90 degrees)	Improved for only 4 hours	No improvement 2 months later	No relief after 4 hours
9	Right sacro-iliac joint and right sciatic nerve	Right sacro-iliac strain with sciatic pain	20 c.c. in right sacro-iliac joint	No improvement	No improvement	No improvement	No improvement
10	Both sacro-iliac joints	Bilateral sacro-iliac strain	10 c.c. in each sacro-iliac joint	Flexion improved Straight-leg raising improved	Improved	Improved 2 years later	Improved 2 years later
11	Left sacro-iliac joint and left sciatic nerve	Left sacro-iliac strain	20 c.c. in left sacro-iliac joint	Straight-leg raising improved (30 degrees to 80 degrees)	Improved	No follow up	
12	Right sacro-iliac joint and right sciatic nerve	Right sacro-iliac strain and postural strain	20 c.c. in right sacro-iliac joint	Flexion improved (2 inches to 0) Straight-leg raising improved (85 degrees to 110 degrees)	Immediate improvement	Improvement lasted a few hours only	
13	Left sacro-iliac joint	Left sacro-iliac strain	20 c.c. in left sacro-iliac joint	Flexion improved (12 inches to 6 inches) Straight-leg raising improved (50 degrees to 90 degrees)	Immediate improvement	Permanent improvement	No pain 5 weeks later

* Flexion = distance in inches by which fingers fail to touch floor in forward flexion.

TABLE I (*Continued*)

RESULTS OF INJECTION OF PROCAINE INTO SACRO-ILIAC JOINT

Case No.	Location of Pain	Clinical Diagnosis	Injection of 1-Per-Cent. Procaine	Immediate Results		Late Results	
				Objective	Subjective	Objective	Subjective
14	Right sacro-iliac joint and right sciatic nerve	Right sacro-iliac strain with sciatic pain	31 c.c. in right sacro-iliac joint	Flexion* improved (8 inches to 5 inches) Straight-leg raising improved (60 degrees to 110 degrees)	Immediate improvement	Improvement 1 month later	
15	Both sacro-iliac joints and both sciatic nerves	Bilateral sacro-iliac arthritis with sciatic pain	20 c.c. in each sacro-iliac joint	Flexion improved Straight-leg raising improved (35 degrees to 50 degrees)	Immediate improvement	Still improved 8 weeks later	
16	Both sacro-iliac joints	Bilateral sacro-iliac strain	15 c.c. in each sacro-iliac joint	Flexion improved (6 inches to 3 inches) Straight-leg raising not improved	Slight improvement	No improvement 1 week later	
17	Right sacro-iliac joint	Right sacro-iliac strain	20 c.c. in right sacro-iliac joint	Flexion improved (3 inches to 2 inches) Straight-leg raising improved (80 degrees to 90 degrees)	Immediate improvement	No follow-up	
18	Right sacro-iliac joint and right sciatic nerve	Right sacro-iliac strain with sciatic pain	30 c.c. in right sacro-iliac joint	Flexion improved (24 inches to 18 inches) Straight-leg raising improved (35 degrees to 60 degrees)	Immediate improvement	Improved 5 weeks later	All pain gone 5 weeks later
19	Right sacro-iliac joint	Right sacro-iliac strain	40 c.c. in right sacro-iliac joint	Flexion improved (18 inches to 4 inches) Straight-leg raising improved (65 degrees to 80 degrees)	Immediate improvement	Improved 4 weeks later	Improved 4 weeks later

* Flexion = distance in inches by which fingers fail to touch floor in forward flexion.

TABLE I (*Continued*)

RESULTS OF INJECTION OF PROCAINE INTO SACRO-ILIAC JOINT

Case No.	Location of Pain	Clinical Diagnosis	Injection of 1-Per-Cent. Procaine	Immediate Results		Late Results	
				Objective	Subjective	Objective	Subjective
20	Right sacro-iliac joint and right sciatic nerve	Right sacro-iliac strain with sciatic pain	20 c.c. in right sacro-iliac joint	No measurements	Immediate improvement	Improved 2 weeks later	Better than in 15 years
21	Left sacro-iliac joint	Left sacro-iliac strain	20 c.c. in left sacro-iliac joint	Much improvement	Immediate improvement	No follow-up	
22	Right sacro-iliac joint and right sciatic nerve	Right sacro-iliac arthritis with sciatic pain	2 injections in right sacro-iliac joint	No improvement after first injection. Immediate improvement after second injection	Improved after second injection	Still well 16 months later	No complaints 16 months later
23	Left sacro-iliac joint	Left sacro-iliac strain	40 c.c. in left sacro-iliac joint	Flexion* improved Straight-leg raising improved (90 degrees to 120 degrees)	Immediate improvement	Marked benefit after 1 week	
24	Left sacro-iliac joint and left sciatic nerve	Left sacro-iliac arthritis	25 c.c. in left sacro-iliac joint	Flexion improved (24 inches to 18 inches) Straight-leg raising improved (30 degrees to 70 degrees)	Immediate improvement	Improved 1 week later	Improved 1 week later
25	Both sacro-iliac joints and both sciatic nerves	Bilateral sacro-iliac strain	22 c.c. in each sacro-iliac joint	Flexion markedly improved Straight-leg raising improved (10 degrees to 60 degrees)	Immediate improvement	1 week later flexion and straight-leg raising improved	Improved 1 week later
26	Left sacro-iliac joint and left sciatic nerve	Left sacro-iliac strain with sciatic pain	20 c.c. in left sacro-iliac joint; repeated in 1 week	Flexion improved (24 inches to 12 inches)	Immediate improvement	2 months later still improved	2 months later still improved
27	Left sacro-iliac joint	Left sacro-iliac strain	20 c.c. in left sacro-iliac joint	Considerable immediate improvement	Immediate improvement	No follow-up	

* Flexion = distance in inches by which fingers fail to touch floor in forward flexion.

TABLE I (*Continued*)

RESULTS OF INJECTION OF PROCAINE INTO SACRO-ILIAC JOINT

Case No.	Location of Pain	Clinical Diagnosis	Injection of 1-Per-Cent. Procaine	Immediate Results		Late Results	
				Objective	Subjective	Objective	Subjective
28	Left sacro-iliac joint	Left sacro-iliac strain	20 c.c. in left sacro-iliac joint	Flexion* improved (16 inches to 9½ inches) Straight-leg raising improved (65 degrees to 85 degrees)	Immediate improvement	3 weeks later: flexion, 6 inches; straight-leg raising, 80 degrees	Much improved 3 weeks later
29	Right sacro-iliac joint	Right sacro-iliac strain	25 c.c. in right sacro-iliac joint	Flexion much improved Straight-leg raising improved (30 degrees to 50 degrees)	Immediate improvement	Improved 1 week later	Improved 1 week later
30	Left sacro-iliac joint	Left sacro-iliac strain	25 c.c. in left sacro-iliac joint	Marked immediate improvement	Immediate improvement	No follow-up	
31	Left sacro-iliac joint and left sciatic nerve	Left sacro-iliac strain with sciatic pain	2 injections in left sacro-iliac joint	Straight-leg raising improved (40 degrees to 95 degrees)	Immediate improvement	No measurements	Slight sciatic pain 12 weeks later
32	Left sacro-iliac joint and left sciatic nerve	Left sacro-iliac strain with sciatic pain	20 c.c. in left sacro-iliac joint	Flexion improved	Immediate improvement	Still improved 4 months later	Very slight sacro-iliac pain 4 months later
33	Both sacro-iliac joints with both sciatic nerves	Bilateral sacro-iliac strain with sciatic pain	20 c.c. in each sacro-iliac joint	Flexion improved Straight-leg raising improved (60 degrees to 90 degrees)	Immediate improvement	Improved 1 week later	Improved 1 week later
34	Right sacro-iliac joint and right sciatic nerve	Right sacro-iliac strain with sciatic pain, spondylolisthesis	10 c.c. in right sacro-iliac joint	Flexion improved Straight-leg raising improved (65 degrees to 100 degrees)	Immediate improvement	Sacro-iliac symptoms improved 2 months later	
35	Both sacro-iliac joints	Bilateral sacro-iliac strain ? tuberculosis of right sacro-iliac joint	15 c.c. in left sacro-iliac joint 5 c.c. in right sacro-iliac joint	Flexion improved (18 inches to 14 inches) Straight-leg raising improved (80 degrees to 90 degrees)	Slight immediate improvement	Improvement lasted 1 or 2 days only	

* Flexion = distance in inches by which fingers fail to touch floor in forward flexion.

TABLE I (*Continued*)

RESULTS OF INJECTION OF PROCAINE INTO SACRO-ILIAC JOINT

Case No.	Location of Pain	Clinical Diagnosis	Injection of 1-Per-Cent. Procaine	Immediate Results		Late Results	
				Objective	Subjective	Objective	Subjective
36	Both sacro-iliac joints	? neurosis Slight atrophic arthritis	10 c.c. in each sacro-iliac joint	Flexion* not improved (2 inches) Straight-leg raising not improved (90 degrees)	No immediate improvement	No improvement	No improvement
37	Left sacro-iliac joint and left sciatic nerve	Left sacro-iliac and mild lumbosacral strain	20 c.c. in left sacro-iliac joint	Straight-leg raising improved, with decreasing pain	Immediate improvement	Improvement still present 1 week later	
38	Left sacro-iliac joint and left sciatic nerve	Left sacro-iliac strain with sciatic pain	20 c.c. in left sacro-iliac joint	Immediate improvement	Immediate improvement	Improvement persisted for 2 months	Free from pain 2 months later
39	Left sacro-iliac joint	Left sacro-iliac strain	20 c.c. in left sacro-iliac joint	Straight-leg raising improved (15 degrees to 90 degrees)	Partial relief	Improvement persisted	No pain 2 weeks later
40	Right sacro-iliac joint	Right sacro-iliac strain Neuropsychosis	20 c.c. in left sacro-iliac joint	Flexion improved (12 inches to 3 inches) Straight-leg raising improved (30 degrees to 90 degrees)	Immediate improvement	2 weeks later flexion and straight-leg raising improved	Improvement 2 weeks later
41	Right sacro-iliac joint and right sciatic nerve	Right sacro-iliac strain with sciatic pain	20 c.c. in right sacro-iliac joint	Flexion improved (20 inches to 10 inches) Straight-leg raising improved (35 degrees to 90 degrees)	Immediate partial relief	Flexion became better Straight-leg raising remained 90 degrees	Improved steadily over next 3 months
42	Right sacro-iliac joint	Right sacro-iliac strain Arthritis of the spine	25 c.c. in right sacro-iliac joint	Flexion not improved (13½ inches) Straight-leg raising not improved (65 degrees)	No immediate relief	No improvement 1 week later	No improvement 1 week later

* Flexion = distance in inches by which fingers fail to touch floor in forward flexion.

TABLE II

SUMMARY OF RESULTS OF PROCAINE INJECTION OF SACRO-ILIAC JOINT

Total No. Patients	No Immediate Improvement	Immediate Improvement			
		Transient	Lasting	Late Results Not Known	Total
42	4	4	25	9	38

explanation of the more lasting results must rest for the present upon theoretical grounds.

The careful studies of Steindler and Luck indicate that, in the majority of cases of low-back pain, structures supplied by the posterior division of spinal nerves are involved, and that the injection of procaine into the tender area causes a disappearance of the local pain, of the pain in the distribution of the sciatic nerve, and of the leg signs. They feel that these results prove the sciatic pain in such cases to be a reflex phenomenon which is associated with low-back disorders. In discussing the benefit obtained from the injection of procaine into the sacral canal in cases of coccygodynia, Suermondt offered two explanations: (1) a mechanical effect on the nerve fibers (swelling from the injection of fluid, followed by a stretching of the fibers), and (2) a toxic degenerative action of the procaine on the sympathetic pain fibers of the coccygeal plexus. Should these theories of Suermondt be correct, they would also explain the beneficial effect of the injection of a large amount of procaine into the compact interosseous sacro-iliac ligament through which pass the nerves supplying the sacro-iliac joint.

Chronic sacro-iliac symptoms may result in defensive spasm of the back muscles with secondary postural abnormalities such as the flattening of the lumbar curve, a list of the spine, and shortening of the muscles of the lower back and thighs. Persistence of these postural abnormalities over a period of time tends to aggravate and to prolong the symptoms of sacro-iliac strain, thus producing a vicious circle. We know, for example, that operations designed to overcome the shortening of the tensor fasciae latae muscle frequently relieve sacro-iliac symptoms and sciatica. In a somewhat similar manner the injection of procaine into the sacro-iliac region produces a transient anaesthesia which permits manipulation and stretching of the tightened structures; thus, the vicious circle is broken, and improvement frequently continues from that time.

Mention should be made of three patients with suspected chronic sacro-iliac strain who observed an improvement in their symptoms and signs for a few hours following the injection of procaine into the sacro-iliac region. In each of these patients, the symptoms recurred on the following day and did not yield to the usual orthopaedic treatment. These patients

were then referred to a neurosurgeon who made lipiodol studies of the spinal canal and demonstrated a deformity of the canal at the level of the fourth or fifth lumbar vertebra. Laminectomy was performed in each case; protrusion of an intervertebral disc was found in two patients, and a thickened ligamentum flavum in the third. In two cases, the symptoms were relieved by operation, and the third case is too recent for the result to be known. We are unable to explain the transient relief of symptoms which followed the injection of procaine in the sacro-iliac regions of these three patients. Possibly the sacro-iliac symptoms were produced by postural strains which resulted from the protective muscle spasm and subsequent ligamentous shortening. This would account for the temporary benefit given by anaesthetizing the sacro-iliac joints.

We must not overlook the fact that this injection may also have a psychic value in that the patient observes himself to bend with greater freedom and notices an improvement in his list and straight-leg raising. Thus may his fear defense reaction be broken down. Whether or not procaine actually enters the sacro-iliac joint is not proved, although anatomical studies in which we injected India ink into cadavera have led us to believe that it does, at least in part. This point is not important because we know that anaesthesia of the sacro-iliac joint results, which aids diagnosis and gives a therapeutic effect.

CONCLUSIONS

1. The injection of procaine into the region of the sacro-iliac joint produces anaesthesia of this joint, which permits the stretching of tight hamstring muscles and manipulation of the joint.

2. This procedure affords a method of determining whether a disorder of the sacro-iliac joint is responsible for the patient's symptoms.

3. Improvement, which was more than transient, resulted in 60 per cent. of a series of patients so injected.

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THE SCIATIC NERVE AND THE PIRIFORMIS MUSCLE: THEIR INTERRELATION A POSSIBLE CAUSE OF COCCYGODYNIA *

BY LINDSAY E. BEATON, M.D., AND BARRY J. ANSON, M.D., CHICAGO, ILLINOIS

From Northwestern University Medical School, Chicago

Considerable interest has recently been expressed in the relation of the piriformis muscle to sciatic pain.[2, 3, 4, 5] In the course of laboratory studies upon various anatomical features, the authors encountered arrangements of piriformis muscle and sciatic nerve which might account for the production of pain in coccygodynia. These anatomical arrangements may be briefly described.

Usually the sciatic nerve emerges from the pelvis by passing beneath the piriformis muscle. The muscle, however, may split into two heads; the nerve may also divide within the pelvis into its tibial and common peroneal portions. Thus six combinations are possible. Only four (Figs. 1, *a* through 1, *d*) of the six types of arrangement have been represented in our 240 specimens examined consecutively; the percentage occurrence of each of the four is recorded in Table I **.

TABLE I

ANATOMICAL ARRANGEMENTS OF PIRIFORMIS MUSCLE AND SCIATIC NERVE

	No. of Cases	Per Cent.
Undivided nerve below undivided muscle	216	90.0
Divisions of nerve through and below divided muscle	17	7.1
Divisions above and below divided muscle	5	2.1
Undivided nerve between heads	2	0.8
Divisions between and above heads	0	0.0
Undivided nerve above undivided muscle	0	0.0

Of our twenty-four cases (10 per cent.) of variations, eight occurred unilaterally. The other sixteen cases were bilateral (that is, on both sides of eight bodies). Of the eight unilateral, three were of the right side, five of the left.

Basing an opinion upon the results of these anatomical observations, it would seem that pain during muscle spasm might be produced through compression of the sciatic nerve, or one of its subdivisions, in those cases in which either the nerve or its subdivision passed between heads of the divided muscle (Figs. 1, *b* and 1, *d*); and that a similar result might follow

* Contribution No. 271 from the Anatomical Laboratory of Northwestern University Medical School.

** To an original group of 120 specimens, previously reported by the present authors,[1] an equal number has since been added, and this table includes both groups.

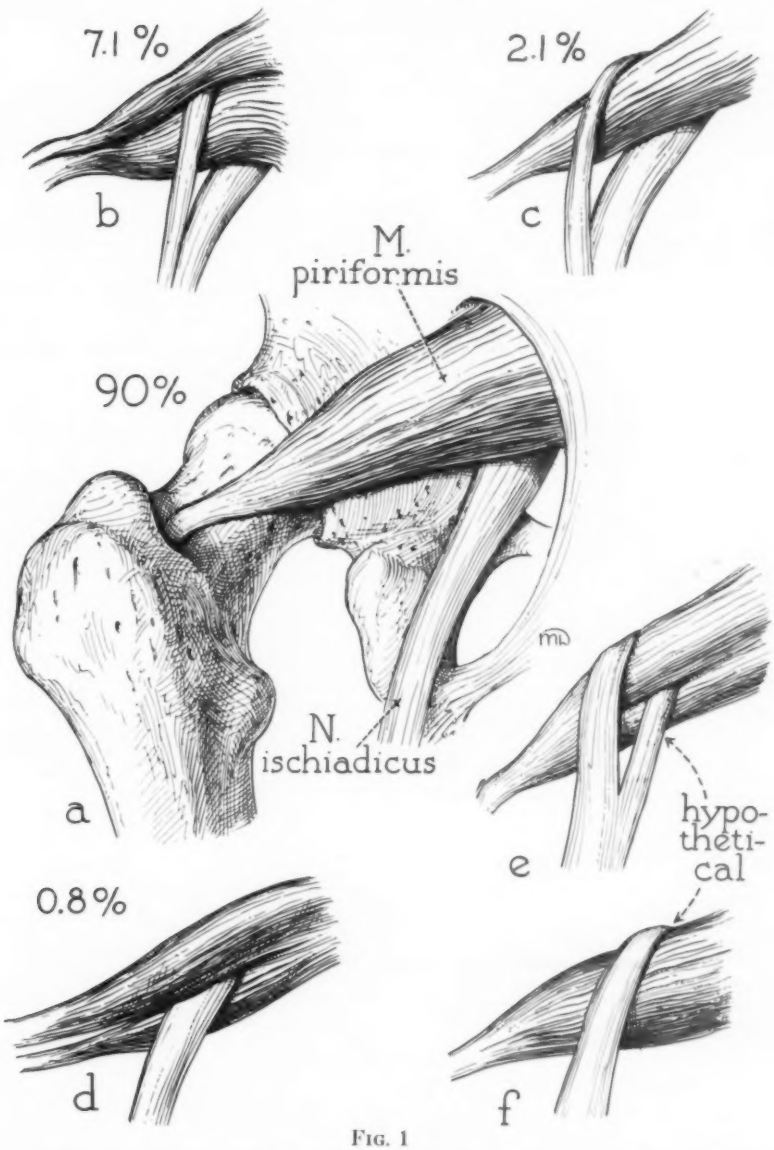

FIG. 1

Six types of arrangement of the sciatic nerve, or of its subdivisions, in relation to the piriformis muscle, arranged in the order of frequency. Gluteal (external) view. The percentage incidence in 240 examples is indicated. Figures *e* and *f* are hypothetical; the others are actual cases.

a: Nerve undivided passes out of greater ischiadic foramen, below piriformis muscle.

b: Divisions of nerve pass through and below heads of muscle.

c: Divisions above and below undivided muscle.

d: Nerve undivided between the heads of muscle.

e: Divisions of nerve between and above heads (hypothetical).

f: Undivided nerve above undivided muscle (hypothetical).

mere stretching of the nerve when it leaves the pelvis superior to the undivided muscle (Fig. 1, *c*). In cases of chronic inflammation of the piriformis muscle, it would seem that any one of these anomalous arrangements of muscle would bring nerve and muscle into closer relationship, and intensify the involvement of the former.

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CORD INJURY DURING REDUCTION OF THORACIC AND LUMBAR VERTEBRAL-BODY FRACTURE AND DISLOCATION *

BY WILLIAM A. ROGERS, M.D., BOSTON, MASSACHUSETTS

Among seventy cases of fracture and dislocation of the thoracic and lumbar vertebral bodies which the author has treated during the past nine years, four are especially notable from the standpoint of cord or root pressure resulting from treatment. Two were fracture-dislocations and two showed crush fractures involving the posterior wall of the centrum with backward displacement of the bone fragments. In all four cases, there was no evidence of cord or root pressure immediately following the injury. In three cases paralysis developed as a result of treatment: in the two fracture-dislocation cases, during reduction; and in one of the fracture cases, two years after the injury. In none of the other sixty-six cases having the usual wedge compression was there the slightest evidence of cord or root pressure incident to treatment.

In view of this experience and because of anatomical and pathological considerations, the writer has divided his cases from the standpoint of cord hazard into two groups,—the safe and the dangerous. The safe group includes all vertebral-body fractures which do not involve the posterior wall of the centrum, probably over 90 per cent. The dangerous group includes all dislocations and all fractures involving the posterior wall of the centrum.

FRACTURE OF THE POSTERIOR WALL OF THE CENTRUM

CASE 1. Figures 1-A and 1-B are the roentgenogram and post-mortem specimen of a woman, aged forty-six, who died of shock a week after she had jumped, with suicidal intent, from a forty-foot height, crushing the feet and ankles and fracturing the second and fourth lumbar vertebrae. The fourth lumbar vertebra was comminuted, and fracture lines involved the posterior wall of the centrum, fragments of which had been forced backward into the neural canal. While there was no clinical evidence of root pressure, Figures 1-A and 1-B show that the lumen of the canal was seriously narrowed. The patient was in severe pain, and symptoms of shock were still present a week after the injury. At that time, in an effort to relieve pain by jacket fixation, an attempt was made to reduce this fracture by traction-extension without altering the shape of the bone in any way.

The author has included this type of fracture in the dangerous group because, obviously, the factor of safety of the cauda equina is low. If the surgeon elects to attempt reduction in these cases, powerful traction should precede and accompany extension. The writer's present policy is not to hyperextend the spine in these cases, but merely to apply jacket fixation to protect the bone until union is complete,—that is, in about four months.

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Los Angeles, California, January 19, 1938.

FIG. 1-A

Case 1. Crush fracture involving the posterior wall of the centrum of the fourth lumbar vertebra. Mild wedge-shaped compression fracture of the centrum of the second lumbar vertebra.

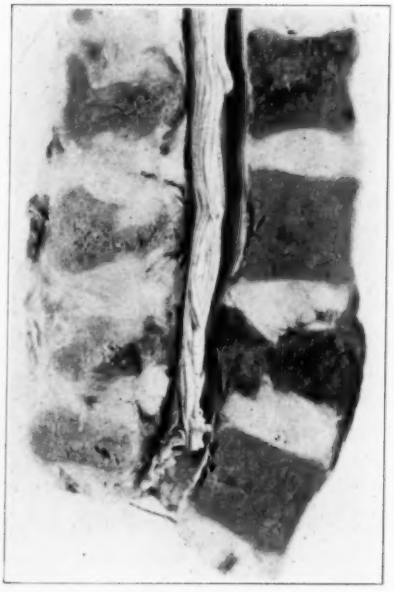

FIG. 1-B

Case 1. Post-mortem specimen.

CASE 2. A boy, nineteen years of age, was injured in an automobile collision in August 1926. He complained of backache. Roentgenographic examination in another hospital was reported negative, and the patient was kept there in bed for three weeks. He then resumed normal activities, and was without complaint for two years when symptoms of cord pressure slowly developed over four months until he could no longer walk because of spastic paraplegia. He was seen by Dr. John Hodgson of the Neurosurgical Service with whom the author saw him in consultation and during treatment. Roentgenograms, unfortunately destroyed, showed an old wedge compression fracture of the fourth thoracic body with massive callus projecting backward into the neural canal. There was a complete block in the canal. These observations were confirmed at laminectomy; cord pressure was relieved at that time by splitting the dura, and further deformity was prevented by spine fusion.

This case illustrates the effect of virtually ignoring a fracture involving the posterior wall of the centrum. Excess posterior callus and increasing deformity finally caused functional interruption in the cord. Laminectomy and spine fusion permanently relieved the trouble.

FRACTURE-DISLOCATION

CASE 3. As shown in Figure 2-A, the patient, a woman, aged thirty-eight, had sustained a fracture-dislocation of the eleventh thoracic vertebra upon the twelfth. After three days of gradual extension on the flexible frame, marked partial motor paralysis of the lower extremities, loss of reflexes, and abdominal distention developed. Extension was at once diminished, and, after three days, all neurological signs had disappeared. The reduction was not completed. (See Figure 2-B.)

Figure 3 illustrates the mechanism of cord pressure which may occur

FIG. 2-A

Case 3. Roentgenogram on admission, showing fracture-dislocation of the eleventh and twelfth thoracic vertebrae.

FIG. 2-B

Case 3. Correction obtained by traction-extension. The dislocation has not been reduced; posterior replacement of the eleventh thoracic vertebra has not occurred.

through manipulative extension in a case of dislocation when the dislocated vertebra does not move backward into normal alignment with its fellows. The author is satisfied that failures to effect posterior replacement have been due to locking of the posterior articulations. This may be demonstrated at open reduction.

CASE 4. The patient, a man of twenty-nine, had been thrown from an automobile. For a day after the accident, there had been little or no evidence of root pressure. Slowly spreading paralysis then developed in scattered groups in both lower extremities. On the third day he was transferred from a distant hospital to the Service of Dr. W. J. Mixter with whom the writer saw him in consultation. Figure 4-A shows the condition on admission. The diagnosis of fracture-dislocation of the first

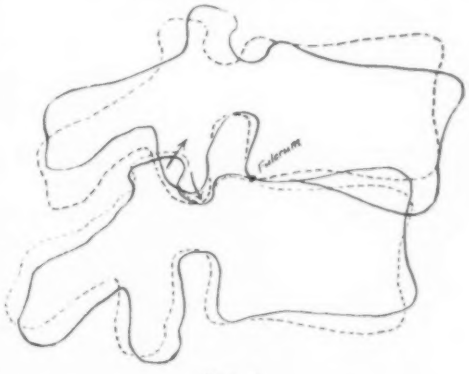

FIG. 3

Diagram showing the effect of extension in fracture-dislocation when the posterior articular processes do not engage normally. If the processes do not lock to prevent further extension, cord or root injury may result from the manoeuver by encroachment of lamina and processes on the neural canal, as occurred in Case 3.

FIG. 4-A

Case 4. Roentgenogram on admission, showing fracture-dislocation of the first and second lumbar vertebrae with partial paralysis.

FIG. 4-B

Case 4. Roentgenogram showing the degree of correction obtained in this case after traction-extension. The dislocation is not reduced; the paralysis is markedly intensified.

lumbar vertebra upon the second was made, and extension was attempted, using ankle traction and suspension with block and tackle.

The usual traction was supplemented by manual traction by assistants before and during the extension manoeuver. Morphine-scopolamine was used. The result is shown in Figure 4-B. All attempts to carry the extension further failed. At the point shown in the roentgenogram, the partial paralysis quickly changed to almost complete paralysis. Open reduction under local anaesthesia was done the same day by Dr. Mixter and the author. When the articular facets were exposed, they were found to be locked as in Figure 5. In order to free and to realign them, it was necessary to flex the column (done by lowering both ends of the operating table) and then to rotate them into align-

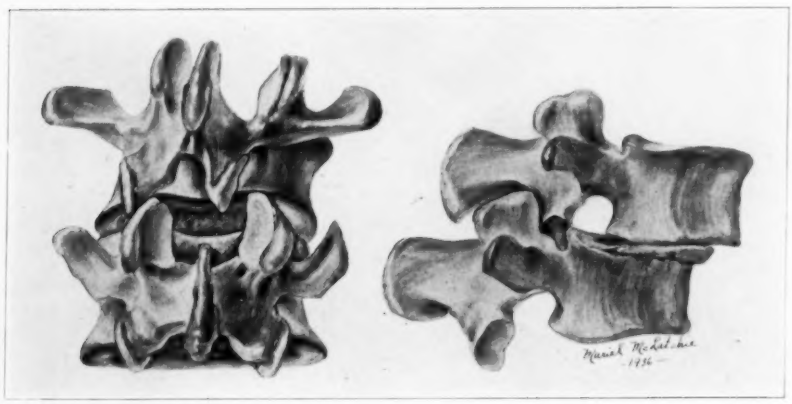

FIG. 5

Case 4. Appearance of the articular processes at operation.

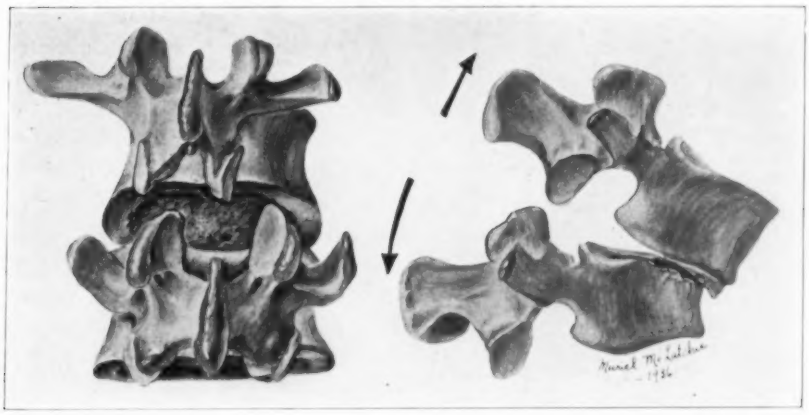

FIG. 6

Case 4. Flexion aided by dissection frees the articular processes.

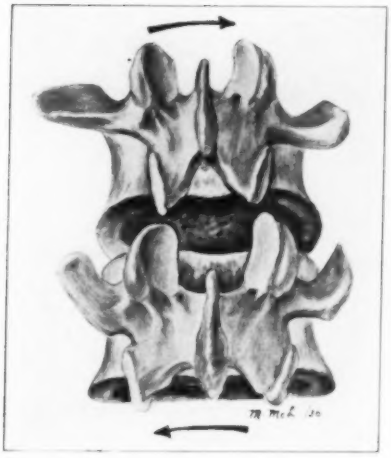

FIG. 7-A

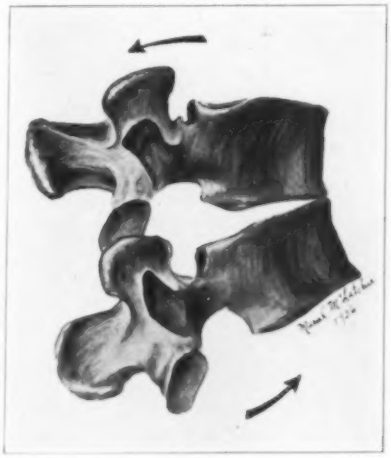

FIG. 7-B

Case 4. Rotation realigns the displaced articular processes.

ment with a periosteum elevator used as a pry. (See Figures 6, 7-A, 7-B, and 8.) Hyperextension could then be accomplished with ease, and the reduction could be completed. The jacket was applied in this position. Figure 9-A shows the immediate result after reduction and Figure 9-B the end result after one year. All neurological signs cleared up, and at the end of a year the patient was symptom-free and able to engage in full preinjury activities.

THE REDUCTION OF DISLOCATION

Based upon the seven cases of fracture-dislocation in the writer's series, the two cardinal points to be considered in the reduction of thoracolumbar and lumbar dislocation are:

1. The condition of the involved articular processes. Are they fractured? What is their relative position?

2. Locking of the articular processes. If the articular processes are

locked, or if it is apparent that they will lock in extension, open reduction should be done, and the processes should be freed by flexion of the column and realigned. Longitudinal traction will not draw the involved vertebrae apart far enough to free the articular processes if they are locked.

If the vertebral body is displaced forward and the articular processes are intact and in normal alignment, as revealed by an anteroposterior roentgenogram taken immediately before reduction, traction and extension will probably effect reduction. This should not be done under a general anaesthetic. Morphine and scopolamine will provide adequate muscle relaxation. If the articular processes do not engage normally during extension, the ma-

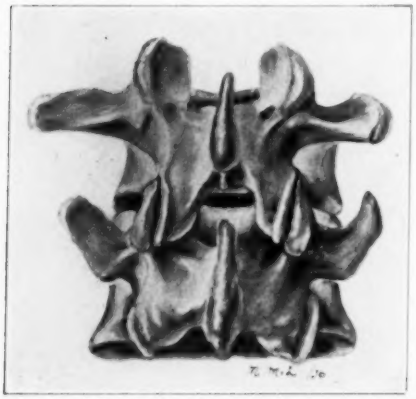

FIG. 8

Case 4. Reduction completed by extension, after realignment of the articular processes.

FIG. 9-A

Case 4. Roentgenogram immediately after open reduction.

FIG. 9-B

Case 4. One year after open reduction. All neurological signs have disappeared.

noeuver should be abandoned, and open reduction should be performed. This may be very difficult, and is always a dangerous operation.

If the vertebral body is displaced forward and the articular processes are not in line (Fig. 5), extension is dangerous and will fail. Open reduction—employing flexion, rotation, and extension in the order mentioned—is the safest and most efficient means at present.

Where displacement of the centrum is lateral, the articular processes are commonly fractured. In such a case they will probably not lock to prevent reduction. Traction and manipulative replacement medially, with or without subsequent extension, are indicated. This manoeuver has been successfully accomplished by Fürster, and others.

In the case of dislocation of the upper thoracic vertebrae, the problem of reduction very rarely comes up. The injuring force either kills the patient or is spent in producing other fractures or dislocations. If the author were confronted with this problem in a patient requiring reduction, he would proceed immediately with open reduction.

CONCLUSIONS

1. Crush fractures, involving the posterior wall of the vertebral body, and all fracture-dislocations are potentially dangerous from the standpoint of cord injury during reduction.

2. In the reduction of vertebral-body dislocation in the thoracic or lumbar region, it is essential that the alignment of the articular processes be determined accurately before reduction is attempted. If there is lateral disalignment, the reduction should be open, and flexion should be employed to disengage the locked processes.

3. Extension of the spine in the presence of vertebral-body dislocation with lateral displacement of the articular processes may injure the cord or nerve roots. It should never be employed until the articular processes are in line.

4. Traction alone will not free locked articular processes.

5. Vertebral-body fracture, involving the posterior wall of the centrum, is potentially dangerous from the standpoint of spinal-cord or nerve-root pressure.

TREATMENT OF INJURIES OF THE CERVICAL SPINE*

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Experience with skeletal traction for reduction of fracture-dislocations of the cervical spine has now been sufficient to prove its value as a method of choice in the treatment of these injuries. Headache and other disagreeable symptoms which may have been expected from the application of a strong pulling force against the skull have not been present. No patient treated by this method has complained of pain in the head or in the neck, only of a pulling sensation in the cervical region when heavy traction is applied.

We have observed no unfavorable results which could be attributed to the use of skeletal traction, except in one patient who was being treated for osteomyelitis of the cervical spine and in whom, after three weeks of continuous traction, a mild bone infection developed around the points of the tongs. Several traumatic cases have been treated for longer periods (three to six weeks) without infection. There has been no augmentation of spinal cord or nerve injury. It is conceivable that prolonged heavy traction could damage the spinal-nerve roots and for this reason, as well as for that of protecting the spinal ligaments, we have not used force in excess of twenty-five pounds.

The potential complications from skull traction are possibly somewhat greater than those arising from the use of skeletal traction elsewhere in the body, but the conditions for which skull traction is applied are such that the risks are more than justifiable.

Any method of treatment applicable to all patients with fracture-dislocations of the cervical spine must be planned in accordance with fundamental nursing requirements. To permit uninterrupted traction during changes of position for protection of the patient's skin, small tongs were designed for application to the vertex of the skull. This instrument was used on all except the first three patients in this series, and to them modified femur tongs were applied. McKenzie uses special tongs that insert into the lateral surfaces of the skull. To obtain traction, Hoen and Cone and Turner insert wires extradurally through burr holes in the skull. While this method is effectual, it requires some knowledge of intracranial surgery, and it is more time-consuming than the application of tongs through which the same effectual traction can be accomplished. Neubeiser inserts hooks under the zygomata. An objectionable feature of this method is that traction is applied in a plane anterior to that of the cervical articulations.

We have used skeletal traction on forty-three patients with recent

* Read at the Annual Meeting of the American Academy of Orthopaedic Surgeons, Los Angeles, California, January 19, 1938.

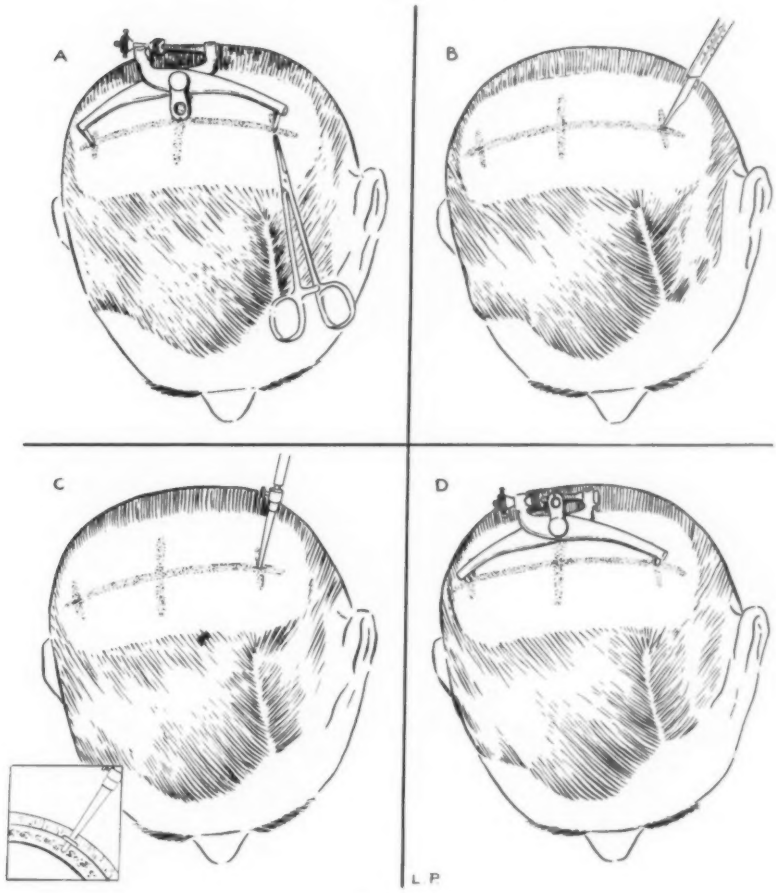

FIG. 1

The author's method of applying skeletal traction for the treatment of fracture-dislocations of the cervical spine.

A: For correct placement of the skull tongs, lines are painted on the scalp to indicate the mid-line of the skull and the approximate plane of the cervical articulations (above mastoid tips). With the traction bar resting on the mid-line, the points of the tongs are brought down upon the transverse line. These points of contact are marked for the placement of stab wounds.

B: After injection of novocain (1 per cent.), stab wounds just large enough to admit the drill guard (inset *C*) are made down to the skull.

C: The drill point is forced to a depth of three millimeters in children and four millimeters in adults. The fixed guard prevents excessive penetration.

D: The points of the tongs are fitted into the bone perforations and held in position until the tongs have been locked. (*Courtesy of the American Journal of Surgery.*)

and old fracture-dislocations of the cervical spine. Of this number, fourteen died as a result of spinal-cord and associated injuries, without follow-up roentgenographic examinations.

Although the results have been analyzed on the basis of the twenty-nine cases with roentgenographic studies during treatment, it should be stated that the relief of nerve-root pain afforded those patients with

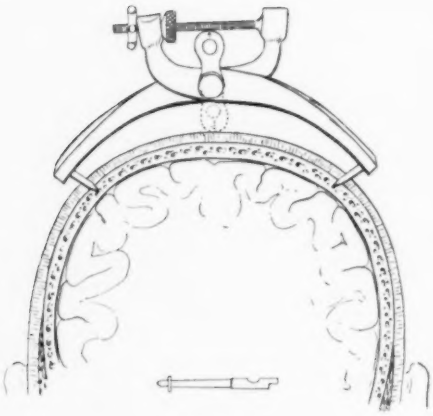

FIG. 2

FIG. 2

Correct position of the points of the tongs. When applied in this manner and tightened daily, especially during the first few days, the tongs will not pull out. The skull should not be drilled blindly except when using a drill point with a fixed guard. (See inset.)

hopeless cord lesions was worthy of the effort expended. Some of these patients were too ill to be disturbed, while others were treated in hospitals without facilities for examination with portable x-ray machines. Apart from the relief of pain, correction of the spinal deformity is desirable in all patients with seemingly hopeless cord lesions, to give them the benefit of any doubt arising from failure to decompress the spinal cord. This applies especially to those patients who receive their first neurological examination several hours or days after injury. During this interval, oedema of the cord or hematomyelia may cause an unobserved

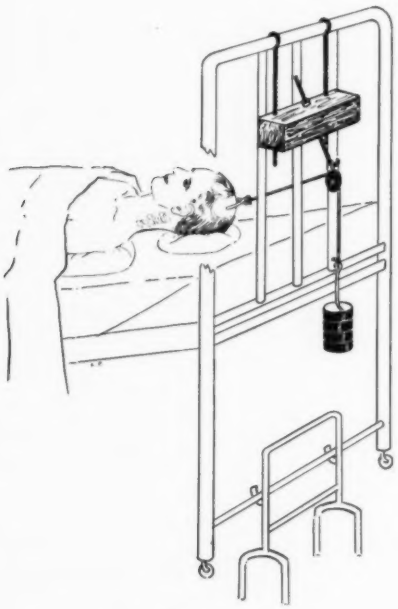

FIG. 3

The traction apparatus is of simple construction and does not hinder the routine care of the patient.

FIG. 4

The patient may be turned to either side while traction is in force. Change of position not only adds to the patient's comfort, but is extremely necessary for the prevention of pressure sores, especially when the spinal cord is severely injured.

FIG. 5-A

Dislocation of seven weeks' duration.

FIG. 5-B

First follow-up film made four days after the application of eighteen pounds of traction. There was relief of symptoms arising from nerve-root injury.

progressive paralysis with clinical findings simulating those of a hopeless cord lesion, but, when these conditions develop under such circumstances, the prognosis would be more favorable than if the same findings were the immediate results of injury.

Skeletal traction affords relief for a group of cases that heretofore presented a difficult problem,—those patients with fractures or fracture-dislocations of the cervical spine, who, for one reason or another, do not receive early treatment. Some patients are not handicapped by reason of an uncorrected spinal deformity, while others are partially or totally disabled as a result of pain, paraesthesia, or paralysis in the upper extremities, due to pressure on the spinal-nerve roots caused by the spinal deformity. In this latter group of cases, even after bone-productive changes are demonstrable, relief of symptoms through partial reduction or disimpaction of a fracture may be obtained by the use of skeletal traction, thus eliminating the necessity for open reduction or the intradural section of sensory roots for relief of intractable pain. The following case is illustrative of this group.

E. P., male, aged twenty-one, fell down a flight of steps on October 23, 1937. When he regained consciousness thirty minutes later, his neck was painful and his arms were weak. On the following day, he complained of a burning, tingling sensation along the ulnar aspects of both arms. In the meantime, motor power had increased. After six days, the right arm was less painful, but, from this time on, there developed a progressive paralysis of the left arm and hand. Upon admission to the hospital, six and one-half weeks after injury, the patient complained of pain and stiffness in the neck, numbness and pain in both arms, and weakness of the left arm and hand. Examination revealed

limitation of motion in the cervical spine and marked impairment of motor function in the left arm and hand. The patient was unable to extend the forearm, hand, or fingers. Also there was inability to move the fingers laterally. Atrophy of the triceps brachii, of the adductor pollicis, and of the interossei muscles was present. Roentgenographic examination revealed an anterior dislocation of the sixth cervical vertebra on the seventh (Fig. 6-A).

Treatment: Skull tongs were applied and to these a weight of twenty-five pounds was attached. The first follow-up roentgenographic examination, made four days later, showed partial reduction. Satisfactory reduction was demonstrated on the seventh day of treatment (Fig. 6-B), following which traction was reduced to fourteen pounds for six days and then to six pounds for three weeks. With traction in force, a plaster jacket was applied.

This patient is now free of root pain; and improvement in motor power, which began within a few days after the application of traction, has continued. Useful function is now present in all muscle groups.

This patient revealed no evidence of spinal-cord injury. His principal disability was caused by progressive nerve-root compression which would have resulted in complete disability of the arm and hand had it not been possible to effect at least a partial correction of the spinal deformity. The results obtained in a similar case are of interest in this connection.

The patient was treated soon after injury and a satisfactory reduction was accomplished. Three and one-half months later, she was referred back to us complaining of severe pain in the left arm and of numbness in the right arm and leg. Roentgenographic

FIG. 6-A

Dislocation of six and one-half weeks' duration.

FIG. 6-B

Result after seven days with twenty-five pounds of traction.

FIG. 7-A

Redislocation. Film made three and one-half months after patient's discharge from hospital.

FIG. 7-B

Slight improvement. Film made eighteen days after continuous application of twenty-five pounds of traction. Relief of nerve-root and spinal-cord symptoms resulted.

examination at this time revealed a more marked deformity than was shown originally (Fig. 7-A). Traction resulted in complete relief of nerve-root and spinal-cord symptoms, but, inasmuch as dense bone-productive changes had already occurred, there was only moderate correction of the spinal deformity, although twenty-five pounds of traction was maintained for one month. (See Figure 7-B.) Since discharge from the hospital three months ago, the patient has had only the support of a Thomas collar, yet there has been no return of symptoms.

In recent cases, reduction is accomplished usually within a few minutes or hours. With the application of efficient and properly directed traction, the danger of an increasing deformity is eliminated, and almost immediately thereafter partial or complete reduction may be demonstrated. Reduction, immobilization in plaster, and removal of the tongs all within a few hours, as advocated by Gallie, are of course desirable and should be practised when possible. In our experience, however, this plan of procedure has not always been practicable, inasmuch as many of our patients have been too ill for immediate immobilization.

The plan of treatment which we usually follow is to apply traction at once, and on the following morning an examination by means of a portable x-ray machine is made. If reduction has been accomplished, those patients with little or no cord injury are immobilized in plaster as soon as circumstances will permit; whereas those patients with complete transverse cord lesions are kept in light traction (four to six pounds) until they

TABLE I

ANALYSIS OF TWENTY-NINE CASES * WITH FOLLOW-UP ROENTGENOGRAPHIC EXAMINATIONS

Cases	Time Elapsing Before Treatment	Result
2	4 months plus	No improvement.
1	2 months	Reduction.
1	7 weeks	Partial reduction.
1	5 weeks	Partial reduction.
1	4 weeks	Reduction.
1	3½ weeks	Partial reduction.
18	3 weeks or less	Reduction.
4	3 weeks or less	Partial reduction.

* Patients treated by Dr. C. C. Coleman and Dr. W. G. Crutchfield, Dr. J. M. Meredith, Dr. E. G. Grantham, Dr. J. L. Thomson, and Dr. E. H. Anderson.

have at least passed the critical ten-day period. Approximately 80 per cent. of the patients in this series with hopeless cord lesions died within ten days. To immobilize these patients in plaster not only adds to their discomfort, but contributes nothing to their welfare.

The results obtained in the twenty-nine cases with roentgenographic studies during treatment are shown in Table I.

The two patients with dislocations of more than four months' dura-

FIG. 8-A

Fig. 8-A: Recent dislocation.

FIG. 8-B

Fig. 8-B: First follow-up film made on the morning following the application of twenty-five pounds of traction.

FIG. 8-B

FIG. 9-A

Recent dislocation.

FIG. 9-B

First follow-up film made on the morning following the application of twenty-five pounds of traction.

tion were treated early in the series, when we were hesitant about the use of a strong pulling force. A maximum of only eighteen pounds of traction was applied,—a force inadequate for reduction in some of the more recent cases.

In all of the twenty-seven cases treated within two months of injury, partial or complete reduction was effected. Reviewed in the light of our present conception of therapeutic force, five of the seven cases showing partial reduction received inadequate traction.

The results as a whole have been encouraging, especially since many of the incomplete reductions occurred early in the development of this method of treatment, when there was no precedent to follow. Proceeding cautiously, the maximum force was increased from nine to fifteen to twenty and then to twenty-five pounds for dislocations in the middle and lower thirds of the cervical spine. In the upper third, ten to fifteen pounds has been sufficient in most of the recent cases. It has seemed desirable to bring about the reduction with a minimal force to prevent soft-tissue injury. Although we have never considered it necessary or advisable to effect a rapid reduction, however, such is possible by increasing the force to a point approaching that used for manual reduction.

NOTE: The author wishes to express his appreciation to Dr. C. C. Coleman, Chief of the Department of Neurological Surgery, for the privilege of presenting this material from his Service, and to Dr. E. G. Grantham for his aid in the preparation of the data

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AN OPERATION FOR THE CORRECTION OF HALLUX VARUS

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Hallux varus is most often of congenital origin and is usually associated with metatarsus varus. Accessory first toes are in the varus position and, after such a toe has been removed, the remaining toe may deviate into this position. A transverse adjoining metatarsal, either of developmental origin or secondary to trauma, may displace the first toe into the position of varus.

The correction of hallux varus may be quite difficult, and it may be necessary to resort to several of the following procedures: wedge resection at the base of the first metatarsal or removal of part of the cuboid, transference of the abductors, osteotomies of all the metatarsals, and transference of an abnormally inserted tibialis anterior. Repeated operations and long maintenance of the feet after operation in corrective shoes or devices are usually necessary for a cure.

The patient in the following case had an extreme type of hallux varus and an associated metatarsus varus, and it is hoped that the operation described may be helpful in other cases of this deformity.

CASE REPORT

The patient, S. H., was a female, aged three years. Because of a disfiguring deformity of the right first toe and difficulty in fitting a shoe, the parents sought treatment.

The patient had been born with six toes on each foot. At the age of six months the extra first toes had been removed from both feet at another hospital. Subsequently, on the right foot the remaining big toe deviated inward and upward. Because of the fixed position, it was quite difficult to get a shoe to fit the foot, and the abnormally displaced toe was quite disfiguring. There was no history of deformity of the feet of any other member of the family.

FIG. 1

Photograph of the patient's feet on admission.

Examination

Examination revealed a moderate pes cavus of both feet. The first toe of the right foot was deviated inward and in dorsal extension; there was also noted a metatarsus varus of the other toes. (See Figure 1.) The extensor hallucis longus and the abductor hallucis tendons were contracted. The displaced big toe had the appearance of an accessory big toe. Roentgenographic examination (Fig. 2) showed the bones of the dis-

placed toe and the metatarsus varus on the right. The tarsal bones all presented ossification centers several years in advance of the patient's bone age. The first metatarsal on the right was short and about twice the normal width. The epiphysis was just beginning to ossify. The head of the first metatarsal was quite irregular, with an oblique, pointed end. The first phalanx was at a right angle to the first metatarsal and had the appearance of an accessory toe.

Treatment

At operation, on February 18, 1935, an incision was made in the old scar on the dorsum of the displaced toe, extending back to the tarsal region. The tendon of the tibialis anterior was found attached to the base of the first metatarsal, from which it was released and transferred back to the cuneiform bone. There were four tendons attached to the metatarsal and the phalanges. The main tendon of the extensor hallucis longus was not disturbed, but the others were severed and allowed to retract. The first metatarsal was broad and looked like two fused bones. The outer half (toward the second toe) was removed. The deviated phalanges were brought over as near as possible to normal position and held with strong sutures. A cuneiform osteotomy was performed at the base of the first metatarsal. Incisions were made over the remaining four metatarsals which were osteotomized near their bases.

Two years after the first operation, the toe deformity recurred almost to its original position. The mother consented to the removal of the toe, as it was of considerable annoyance and discomfort to the child and it was difficult to get a properly fitting shoe. From a functional standpoint this displaced toe was of little value, but it was thought that its replacement would improve the appearance of the foot and save the child some embarrassment. Another attempt seemed warranted before sacrificing the toe.

FIG. 2

Roentgenogram of the patient's feet on admission.

FIG. 3

Diagrammatic drawing of the right foot after the second operation, showing the loop of tendons extending around the first phalanx of the big toe and the second metatarsal.

A: Extensor hallucis longus.

B: Site of suture.

C: Accessory extensor hallucis longus.

FIG. 4

Roentgenogram of the right foot, taken on November 18, 1937, showing the position of the first toe and a good correction of the metatarsus varus.

FIG. 5

Photograph of the patient's feet five months after the second operation.

Therefore, on September 20, 1937, a second operation was performed. An incision was made in the old scar on the dorsum of the first toe. The extensor hallucis longus tendon was severed well up in the tarsal region and the proximal end was sutured to the tibialis anterior tendon. The distal portion of the tendon was pulled down to its insertion. The first phalanx was then lined up with the metatarsal by removing some of the head of the metatarsal and by an osteotomy of the first phalanx. The free end of the extensor hallucis longus tendon, which had been pulled down to its insertion, was passed around the inner side and under the first phalanx to the under surface of the second metatarsal. It was then brought around the lateral border of the second metatarsal. The accessory extensor hallucis longus tendon was then severed at the base of the first metatarsal, and the free distal end was pulled over to the second metatarsal, where it was united to the free end of the main tendon

which had previously been brought under the second metatarsal. Thus there was a loop of tendons extending around the first phalanx of the big toe and the second metatarsal. (See Figure 3.) The wound healed normally. Before the patient was dismissed from the hospital, a metatarsal plate was fitted under the right foot. The roentgenogram (Fig. 4) shows the position of the first toe and a good correction of the metatarsus varus. An accessory cuneiform is seen on the medial side of the tarsal region. The final result is shown in Figure 5, five months after operation. The first toe is in good alignment and has only a slight tendency toward dorsal extension.

CONCLUSIONS

Marked hallux varus may be corrected by a tendon-loop operation around the first phalanx and the second metatarsal. The extensor hallucis longus tendon was utilized in the case described, but a free tendon graft from one of the other extensor tendons could also be used for the same purpose. Osteotomies of all the metatarsals are necessary if there is an associated metatarsus varus of the other toes.

OSSIFICATION IN THE LIGAMENTS OF THE ELBOW JOINT *

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This condition can be termed "arthritis ossificans ligamentosa" of the elbow,—a name which corresponds to spondylitis ossificans ligamentosa, the only disease in which there is extensive ligamentous ossification. Ossification of ligaments occurs in the spine and in the elbow and ankle joints, but seldom elsewhere except in association with osteo-arthritis. Possibly the post-traumatic condition, called Pellegrini-Stieda fracture or lesion, [1, 2, 3, 4] is an ossification of a portion of the tibial collateral (internal lateral) ligament of the knee.

The formation of bone in muscle around the elbow has attracted much attention, but it appears that the changes in ligaments are seldom mentioned, although the two are not infrequently associated. Ossification in the ligaments of the elbow joint is usually traumatic in origin and is probably more common than in the ligaments of any other joint. It occurs particularly after dislocation and after injuries on the outer side of the elbow. It is seen, but does not necessarily occur, after an operative procedure on the joint. The causation of the ossification in the majority of cases can be termed *mechanical* and is due to avulsion of the attachment of the ligament. One end of the ligament is torn away from the bone and carries with it a small piece of periosteum; a hematoma results and bone cells are activated, so that the torn end of the ligament becomes united to the bone from which it was torn by a piece of bone, or by fibrous tissue in which there is a piece of bone. The quantity of bone formed is dependent on the treatment. With rest, little or no bone formation occurs, but massage and movements encourage it greatly. Ossification under the periosteum on the front of the humerus and in the brachialis and other muscles (for example, those arising from the epicondyles and supracondylar ridges) may be present at the same time. Such sequence of events is well known.

A study of the records and roentgenograms in cases of severe elbow injury showed that in the majority of dislocated elbows which were followed by serious ossification of the ligaments:

1. The primary reduction of the dislocation and the first two weeks of treatment were not carried out at an organized fracture clinic;
2. There was a small fracture as well as the dislocation;
3. Movement by manipulation under anaesthesia or passive movement had been employed subsequent to the primary reduction of the dislocation.

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It is recognized that in a dislocation the radial and ulnar collateral ligaments * are usually torn from the humerus and a small flake of bone, to which the ligament is attached, may be separated. It appears that the portion of bone torn from the outer side may consist of the lateral epicondyle and a strip of bone from the external supracondylar ridge (Fig. 1). After reduction of the dislocation, this strip of bone may remain displaced nearer the joint line and may enlarge, both in length and thickness, as union occurs. Fortunately, in some cases, after reduction of the dislocation, the fragment of bone slips back into place.

FIG. 1

A female, aged fifteen, dislocated her elbow on May 5, 1937. The dislocation was immediately reduced and the elbow was immobilized in a sling for two weeks, followed by massage and exercises. On June 11, 1937, there was 15 degrees of movement. Roentgenographic examination showed myositis ossificans and a fracture on the outer side of the joint. The joint was put at rest. The roentgenograms shown above were taken on August 11, 1937. Subsequently, the plaque of bone was removed from the outer side of the joint, and movement was returning satisfactorily.

Lateral view: Subperiosteal new bone in front of the lower end of the humerus.

Anteroposterior view: Small area of bone in the ulnar collateral ligament and a large plaque of bone on the outer side, which is partly a piece of bone fractured and displaced down from the lateral supracondylar ridge. New bone formation has occurred at its lower end. (This view was taken at a right angle, as movement was then negligible.)

The effect of forcible manipulation during the healing process of a fracture-dislocation of the elbow is well known, but it should be stressed as it may be very serious. The formation of bone under periosteum, in muscle, and in the anterior part of the capsule may be so extensive that the small amount formed in the collateral ligament is of relatively little importance. (See Figure 2-A.)

* External and internal lateral ligaments.

When the primary injury to the elbow is a fracture without dislocation, it may not be known whether or not there was ligamentous injury at the same time. The existence of the latter is probably the cause of some of the cases showing ossification later. It is relatively common in the proximal end of the radial collateral ligament after fracture of the head of the radius.

FIG. 2-A

FIG. 2-B

A female, aged thirty-seven, had received a compound dislocation of the elbow which was said to have been reduced in February 1932. The elbow had become stiff and had been manipulated under anaesthesia. In June 1932 the elbow had no movement, and there was a complete ulnar paralysis (Fig. 2-A). In July 1932 an arthroplasty with freeing of the ulnar nerve was done, and in December 1933 the head of the radius was removed. In October 1937 examination revealed flexion to 60 degrees, extension to 120 degrees (60 degrees of movement), and full pronation and supination. There was complete recovery of the ulnar nerve.

Fig. 2-A: Four months after injury, showing unreduced dislocation with extensive ossification, especially of the anterior ligament.

Fig. 2-B: Five years and eight months after injury.

An important matter for consideration is whether or not bone is formed in ligaments after operations on joints. Certainly it may be so formed, but this is not necessarily the case. Bone is liable to form after an operation for the removal of the head of the radius, when it is undertaken shortly after the injury, but it is less liable to form when the operation is carried out at a later date. Probably the liability is greater when there is a quantity of blood in the joint or in the wound, but extensive operations for fracture are not necessarily followed by ossification. The use of a tourniquet may be a factor in diminishing the chance of bone formation.

It is noticeable that the ossification of the ulnar collateral ligament is often irregular, so that the roentgenogram shows what is termed "droplet formation" of bone (Fig. 3). The cause of this droplet forma-

tion the writer is unable to explain. This should not be confused with a loose body in the joint, nor with a displaced medial epicondyle. Striae in an osseous shadow indicate that the bone formation results from an avulsion fracture, and is not due to ossification of the ligament. There seems no justification for naming ossification of the ligaments "osteo-arthritis", as is not infrequently done.

In some of the roentgenograms showing droplet formation, there is quite a space between the droplets and the medial epicondyle. In some cases there is sufficient evidence to show that periosteum has been torn off. However, the case of a man, aged thirty-five, affected with *hemophilia* is interesting. He was not aware of any severe injury at any time, but he had had a swollen elbow a number of times. The roentgenogram (Fig. 4) shows the droplet formation.

FIG. 3

Droplet formation of bone in ulnar collateral ligament following dislocation in a male, aged forty-six. The dislocation was reduced on the day of the injury. The roentgenogram shown above was taken three months after injury. Two years after injury the roentgenographic appearance was similar, and the patient had limitation of extension and flexion of 20 degrees in each direction.

In such a case it may be contended that:

1. The ligament has been split in the length of its fibers by injury;
2. Blood has run down between strands of the ligament;
3. Bone cells have been carried by the blood from a torn periosteum at the epicondyle;
4. The tiny hematomata have become isolated and ossification has occurred in each.

On the other hand, ligaments do not tear into shreds very easily, except by severe trauma; the condition is rare in other parts of the body and this sequence of events seems improbable in the hemophilic joint.

Another change in this region is of interest—namely, calcification. The author is indebted to Mr. H. A. T. Fairbank for Figure 5; he recognized an area of calcification, not ossification, adjacent to the lateral epicondyle. This area may be formed in the muscle attachment and may be similar to that occurring in the tendon of the supraspinatus and in the tendo achillis.

SYMPTOMS

The existence of large plaques of bone produces stiffness. If the elbow is put at rest as soon as ossification is recognized, the condition may not be painful. Small fragments usually cause slight stiffness and

FIG. 4

Droplet formation of bone in ulnar collateral ligament in a hemophilic joint in a male, aged thirty-five.

FIG. 5

Area of calcification adjacent to right lateral epicondyle in a female, aged thirty-five. The patient gave a history of injury to the right or left elbow. When seen there was acute pain and swelling in the outer side of the right elbow joint. The temperature was 100 degrees. Movements were painful in the extremes, but not obstructed. The acute condition had subsided under antiphlogistin.

may produce limitation of movement, or there may be no symptoms at all.

When there is a piece of displaced bone as well as ossification in the ligament, the limited movement is dependent on the former.

CAUSATION

There is ample evidence that myositis ossificans will not form unless two factors—traumatic and mechanical—are brought into action.[5] As the latter is avoidable by putting the limb at rest, one would suppose that myositis ossificans need never occur. However, this is not the case with mild degrees of ossification of ligaments. Gross changes, and probably an increase in the extent of ossification, are the result of forced movement or massage, but not the cause of small areas of bone formation. Hence, the gross changes will be prevented by immobilization.

It is recognized that subperiosteal new bone formation may occur on the fibula in cases of osteomyelitis of the tibia; this is supposed to be due to oedema which raises the fibular periosteum. If oedema affects the ligaments, it will facilitate bone formation if bone cells are present, but in the droplet type of case their presence can be accounted for only by shredding of the ligaments, when a hematoma is probably present.

In the cases which the author has examined, small areas of ossification were as frequent when the dislocation had been reduced within a few hours as they were after twenty-four hours. In most of the cases almost immediate reduction was carried out, so theoretically the periosteum or

bone fragments had been replaced. It may be contended that the ossification seen in some of the roentgenograms is in the aponeurosis of the common flexors. This tissue is somewhat like ligamentous tissue, and formation of bone in the tissue will be of comparable origin.

TREATMENT

These points are raised in order to arrive at the correct *preventive treatment.* Immobilization limits excessive bone formation and is, therefore, advisable. Movement and massage are harmful. Fixation is usually carried out over too short a period; a period of from ten to fourteen days does not allow time for the absorption of blood and the healing of the ligaments. Healing certainly requires three weeks and longer in cases where much swelling and bruising are present. There is no evidence that immediate and complete immobilization has any effect on the formation of small plaques of bone.

When it is recognized that ossification exists in muscle around the elbow, it is fortunate that absorption—partial or complete—will occur if the part is immobilized.

As a rule, once bone is formed in ligament, it remains unchanged. Possibly the ligaments are too avascular to carry out the process of absorption. Rarely, the joint may subsequently undergo the changes of traumatic osteo-arthritis, but this may be the result of the primary injury rather than of the ligamentous injury. When the osseous formation is small and the period of treatment of the primary lesion has been completed, it is best to leave the condition untreated, especially in cases showing droplet formation. In severe cases, it is advisable to put the part at rest in order that the oedema may subside, and localization and consolidation of the bone may occur; if muscle is also implicated, such a line of treatment is rational. Then plaques can be removed or a more extensive operation such as arthroplasty can be planned to regain movement. (See Figure 2-B.)

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AN OPERATION FOR THE CORRECTION OF HAMMER-TOE AND CLAW-TOE *

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In this paper the treatment of the entities known as hammer-toe and claw-toe will be considered together, because from the standpoint of treatment the deformity is very similar, although it is in a milder form in claw-toe as a rule. Hammer-toe commonly occurs singly in one or both feet, the second toe being most frequently affected. Claw-toe is usually bilateral, the deformity being present in all the digits. However, varying degrees of the deformity may occur in any number of toes. In this condition, the structural abnormalities which require correction are as follows: dorsiflexion contraction of the metatarsophalangeal joint, plantar-flexion contraction of the proximal interphalangeal joint, and plantar-flexion or dorsiflexion contraction of the distal interphalangeal joint. The extensor and flexor tendons show a contracture of their muscles, while there is shortening of the ligaments, skin, and other soft parts in the concavity of the flexures.

Theoretically, the spike operation of Higgs seems to be an improvement on all prior operations and to offer a rational procedure to overcome this deformity. However, it presents technical difficulties which will be mentioned. In this operation, after a transverse incision has been made, the head of the proximal phalanx is shaped with bone forceps so that it resembles a pointed spike. The cartilage is removed from the base of the intermediate phalanx "and a hole is bored up into the shaft of the bone. . . . The pointed first phalanx is then spiked into the second phalanx." The difficulty here is the fact that the head and distal end of a phalanx are made up of cancellous bone, a very thin cortex, and cartilage. When the head is shaped to resemble a spike, the cartilage and cortex are removed, leaving the fragile cancellous bone which is easily broken when it is thrust into the intermediate phalanx. The spiked end cannot be impacted firmly and will rock in its new position, so that it is difficult to splint to prevent displacement or fracture of the spiked end of the first phalanx during the healing process.

An operation which appears to be satisfactory was worked out independently by the writer without knowledge of the Higgs operation. Through a very short linear incision over the dorsal aspect of the metatarsophalangeal joint, a tenotomy of the long and short extensor tendons is performed after they have been hooked up into the wound. In severe cases it is necessary to incise a tight fibrous band which extends across the

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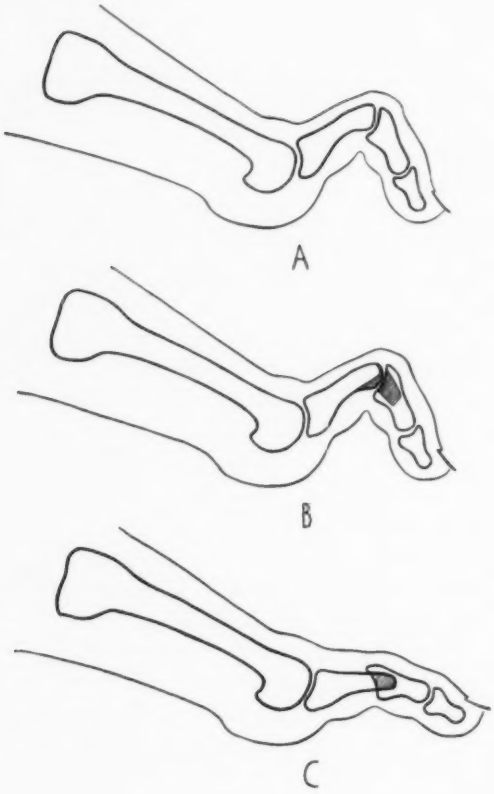

FIG. 1

A: Lateral view of the bones in a hammer-toe.
B: The head and distal extremity of the proximal phalanx are reshaped to resemble a truncated cone. Attention is called to the intact central part of the dorsal cortex. The cavity made in the base of the second phalanx is represented by the shaded area.
C: The distal extremity of the proximal phalanx is fitted into the base of the second phalanx.

dorsum of the metatarsophalangeal joint. In the operation on the toe itself, a linear incision is made over the dorsal surface of the proximal interphalangeal joint, lateral or medial to the extensor tendon to avoid the danger of cutting both dorsal digital arteries, which is frequently done when the transverse incision is used. The digital artery in the line of the incision is sought and ligated with triple 0 plain catgut, if it is found to be injured. The expansion of the long extensor tendon is exposed and divided transversely one-half a centimeter proximal to the joint. The distal end is reflected forward to expose the joint surfaces. The distal extremity of the proximal phalanx is dissected free from the collateral and plantar ligaments and other structures to expose the head and part of the shaft of the bone. By means of small dental rongeur forceps, the cartilage is excised from the head of the phalanx, and the end of the bone is reshaped to resemble a truncated cone. However, it is important not to remove all of the dorsal cortex, because the central part of it is necessary to maintain the required strength of the bone. A drill hole is made in the middle of the joint surface of the base of the second phalanx to penetrate the marrow cavity. This hole is gently enlarged with a very small gouge, and sufficient bone and marrow are excised to make a cavity the size and shape of the new form of the distal end of the first phalanx. The latter is fitted firmly into this cavity, the connection being similar to that by which the sections of a trout pole are joined. Care must be used not to have a rotation of the second phalanx on the proximal phalanx in this union of the two phalanges. The extensor-tendon expansion is united with a mattress suture of silk after a small section of it has been excised to take up the slack in its length. The skin closure is done with silk sutures, and im-

mobilization is maintained with metal or molded plaster splints. A splint is advisable because, on recovering from the anaesthetic or at other times, the patient may inadvertently contract the flexor digitorum longus muscle forcibly and disturb the position of the phalanges. We allow our patients to walk three weeks after operation, but the author believes that in some cases this time can be lessened.

This hammer-toe operation has been performed on the interphalangeal joint of the great toe in one case of claw-toe, and the result was satisfactory.

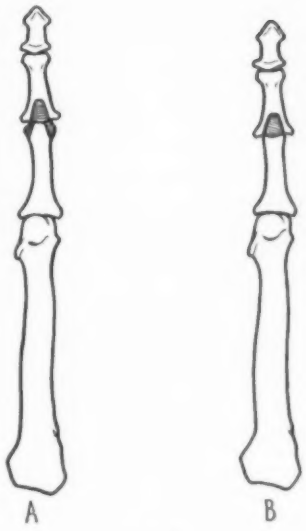

FIG. 2

A: Diagram illustrating the reshaped distal extremity of the proximal phalanx and the cavity made in the base of the second phalanx of a hammer-toe, seen from the dorsal aspect.

B: Dorsal view of the proximal and second phalanges as fitted together by the arthrodesis.

COMMENT

In severe cases of dorsiflexion contraction of the metatarsophalangeal joint, the extensor digitorum longus tendon is displaced from its normal position as the dorsal part of the joint capsule and lies subcutaneously. The band of fibrous tissue which must be incised in these cases extends across the joint on its dorsal aspect to close the capsule. In order to expose this band and to avoid injury to vessels and nerves, excellent retraction can be obtained through a short incision by inserting straight Kelly forceps through the subcutaneous tissues to the joint, where the blades are opened and spread so that one blade is placed on each side of the joint.

The shortening of the toe by this operative procedure is not greater than that produced by other arthrodesing operations. However, this shortening, which is usually about five or six millimeters, is equivalent to lengthening the soft parts distal to the metatarsophalangeal joint. This assists in overcoming the flexion contraction of the proximal interphalangeal joint where the flexor digitorum longus tendon, the plantar ligament, and the skin are the most resistant structures. The shortening of the phalanges also makes the expansion of the extensor digitorum longus tendon redundant, because this tendon is inserted into the proximal phalanx and, therefore, the slack cannot be taken up by retraction of the extensor muscles. This makes it necessary to excise a short section of the expansion of the extensor tendon as described.

In some cases of severe deformity, it is advisable to perform the operation in two stages. The arthrodesis of the proximal interphalangeal joint may be performed primarily. The resulting ankylosis provides stability in the toe, so that pressure on its dorsal surface will maintain correction

FIG. 3

J. K. Illustrative case of hammer-toe, showing arthrodesis of the proximal interphalangeal joint of the right second toe, nine months after operation.

In this common type of hammer-toe, as well as in claw-toe deformity, there is an assurance of ankylosis.

FIG. 4

R. O. Illustrative case of claw-toe, three months after arthrodesis of the interphalangeal joint of the great toe and proximal interphalangeal joints of the second and third toes. The distal half of the proximal phalanx of the fifth toe has been excised. No operation was performed on the fourth toe.

during healing after the tenotomy of the extensor tendons and division of the fibrous band over the metatarsophalangeal joint.

FIFTH-TOE DEFORMITIES

Claw-toe deformity of the fifth toe presents a different problem, and the operation as outlined does not apply to it, because the second phalanx (or fused second and distal phalanges) is too small to be used for such an operation. For the same reason, no arthrodesing operation is practical on the fifth toe. Amputation in these cases is recommended by most textbooks as the only means of cure for the deformity and relief from painful keratoses. However, amputation is a mutilating procedure, and the writer has been using another operation for several years.

A linear incision is made on the mediodorsal aspect of the fifth toe from a point one-half a centimeter distal to the head of the proximal phalanx to a point one-half a centimeter proximal to the metatarsophalangeal joint. The extensor tendon is tenotomized over the metatarsophalangeal joint to diminish the dorsiflexion contraction. The expansion of the tendon is also tenotomized one-half a centimeter proximal to the head of the proximal phalanx, and its distal end is reflected forward to expose the joint. The distal extremity of the proximal phalanx is dis-

sected free from ligaments, and the soft structures are reflected from the shaft extraperiosteally. The head and distal fourth, half, or two-thirds of this phalanx are excised with bone-cutting forceps, the amount of excised bone depending on the size of the toe or the severity of the deformity. The extensor-tendon expansion is united with a mattress suture.

The fifth toe will be flail following this procedure, but this is no particular disadvantage, because, although shortened, this toe is maintained in its position against the fourth toe, and the patients do not complain. In some cases where the fifth toe is in an extreme dorsal position, it is necessary to perform a plastic lengthening of the skin posterior to it by making a V incision and suturing it as a Y.

Keratoses on the medial aspect of the fifth toe and on the lateral side of the fourth toe are caused by compression of the skin and friction between the head of the proximal phalanx of the fifth toe and the base or shaft of the proximal phalanx of the fourth toe. The operation as described will relieve these keratoses as well as those on the lateral aspect of the fifth toe.

CONCLUSIONS

1. Hammer-toe and claw-toe deformities are treated most satisfactorily by lengthening the contracted soft structures and by performing an arthrodesis on the proximal interphalangeal joint.

2. An arthrodesis is assured by reshaping the head and distal extremity of the proximal phalanx to resemble a truncated cone and fitting it into a cavity of like shape in the base of the second phalanx.

3. Claw-toe deformity of the fifth toe is not amenable to treatment by an arthrodesing operation, but the deformity and keratoses may be relieved by excision of the head and a portion of the shaft of the proximal phalanx.

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ISOLATED PARALYSIS OF THE SERRATUS ANTERIOR (MAGNUS) MUSCLE*

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In 1825, Velpeau described a case of winged scapula attributable to paralysis of the serratus anterior (magnus) muscle, and since then over 150 cases have been reported. It is believed that most cases are due to injury or to disease of the long thoracic nerve rather than to laceration of the muscle itself, in the absence of such local findings as muscle tenderness, swelling, and ecchymosis. Only one author (Fitchet) claims to have been able to palpate a hiatus between what he interpreted as the retracted portion of the muscle and the scapular border.

Four cases of localized paralysis of the serratus anterior are herein presented, and two additional cases are briefly alluded to.

CASE 1. H. C., a white male, aged thirty-five, severely wrenched his right shoulder in hoisting a 250-pound load on September 6, 1929. He experienced immediate and thereafter constant pain in the region of the right shoulder, and was unable to elevate the right arm above the horizontal plane. He was seen by one of us in May 1930, after having received varied treatment without benefit. Examination at this time showed tenderness in the region of the coracoid process, of the superior internal angle, and of the vertebral border of the scapula; drooping of the right shoulder girdle; weakness and limitation of active abduction to 20 degrees below the horizontal plane; and marked winging of the right scapula. Roentgenographic examination of the right shoulder was negative. Electrical stimulation revealed paralysis of the serratus anterior muscle, and weakness of the middle portion of the trapezius and of the posterior portion of the deltoid muscles.

The patient's response to local heat, galvanic stimulation, massage, and a supportive brace (Figs. 1-A, 1-B, 1-C, and 1-D) was striking, a complete cure being effected in six months. Nocturnal discomfort was eliminated early in the treatment by avoidance of the supine position.

CASE 2. M. B., a white male, aged thirty-five, noted the onset of pain and tenderness in the region of the right shoulder, associated with winging of the right scapula, in August 1930, following overexertion in several strenuous tennis matches and occurring during an attack of conjunctivitis. The diagnosis of localized paralysis of the serratus anterior muscle was corroborated by electrical-reaction studies, and the patient experienced gradual recovery following self-imposed exercises. Roentgenographic examination of the shoulder was negative.

Examination by one of us in April 1931 revealed drooping of the right shoulder and residual winging of the scapula. The patient was advised to assume the prone posture in sleeping, to institute electrical stimulation, and to continue with his exercises. The patient reported complete recovery in June 1931.

CASE 3. S. J., a white male, aged thirty-nine, was seen in July 1937, complaining of pain in the region of the right shoulder of one week's duration, occurring during a severe head cold and following the bearing of 200-pound loads on the right shoulder for several days. Examination revealed localized tenderness in the region of the coracoid process and definite winging of the right scapula. Roentgenographic examination of the cervical spine and shoulder was negative. Electrical stimulation elicited a weakened response from the right serratus anterior muscle, the mid-portion of the trapezius muscle, and the

*This study has been partly aided by a grant from the J. Ewings Mear Research Fund, Jefferson Medical College, Philadelphia.

FIG. 1-A

FIG. 1-B

FIG. 1-C

FIG. 1-D

Figs. 1-A, 1-B, 1-C: Showing the upward and backward thrust of the shoulder girdle by the brace described in the text.

Fig. 1-D: Illustrating the celluloid elbow rest, the adjustable steel upright, the chest band, and the pelvic band with the iliac-crest piece.

posterior portion of the deltoid muscle. The patient was instructed to sleep on the abdomen. Local heat and electrical stimulation were administered, and a brace (Figs. 1-A, 1-B, 1-C, and 1-D) was applied. This treatment resulted in early subsidence of acute manifestations and complete recovery in one month.

CASE 4. C. W., a white male, aged thirty-seven, injured his right shoulder in a direct fall, and experienced pain and tenderness in the right scapular region of several weeks' duration. Roentgenographic examination of the affected shoulder was negative. He was seen by one of us in March 1938, eight months after injury, complaining of weakness in the power of the muscles of the right arm and shoulder girdle. Examination revealed a paralysis of the right serratus anterior muscle and weakness of the posterior part of the deltoid; this was corroborated by electrical studies. The patient is responding favorably to our treatment.

CASE 5*. A white male, aged fifty-five, had a localized paralysis of the right serratus anterior muscle with winging of the scapula, which had occurred during an attack of influenza. The upper scapular region was swollen and extremely tender to pressure. The patient was treated with rest and physical therapy for six months. At the end of two years a slight weakness of the serratus anterior muscle persists.

CASE 6*. A white male, aged thirty-five, suffered a localized paralysis of the left serratus anterior muscle, following a severe blow to the left scapular region in an automobile accident. He experienced immediate pain, swelling, and tenderness in the region of the left shoulder, and shortly thereafter he noted winging of the left scapula. Slight weakness of the serratus anterior still persists one year and three months after injury.

PATHOGENESIS

Trauma (direct or indirect, acute or chronic) to the neck, shoulder, or scapula regions is a primary etiological factor. The occurrence of paralysis during infections and the presence of systemic and local manifestations are indicative of an infectious factor.

The results of a study by the authors of 100 anatomical specimens, to be published in a separate communication, are briefly:

1. A likely site for localized injury to the long thoracic nerve, following its complete formation, is where it courses between the coracoid process and the lateral costal cage (second rib). In addition, the nerve is found to become definitely angulated as it crosses the second rib and its overlying heavy musculature. A downward thrust of the shoulder girdle, or a lateral tilt of the head and neck in the opposite direction, places the nerve on stretch and increases its angulation over the second rib.

2. Morphological variations in the formation and the course of the long thoracic nerve are influential, and serve to explain why identical traumata in different individuals only infrequently result in this lesion.

3. Four bursae—the subcoracoid, the subscapular, the accessory subscapular, and the supracoracoid—are adjacent to the nerve. If these normal bursae, or adventitious bursae which develop as a result of occupation (Torraca), become enlarged due to trauma, to infection, or to both, they may exert a direct mechanical (pressure) effect on the nerve, or the nerve may become inflamed by contiguity.

4. These factors are all exaggerated by the supine posture, and one can readily associate the effect of nocturnal compression on our patients and the permanent relief experienced by them upon assuming the prone or contralateral side position in sleeping. The reported occurrences of paralysis of the serratus anterior in prolonged obstetrical and surgical cases, and in those long bedridden (Bertrand and Chailly; Thorek; Tavernier; Guillain and Libert; Berkheiser and Shapiro), may be explained in part by the mechanical insult of the supine position.

KINESIOLOGICAL OBSERVATIONS

"Winging" of the scapula becomes most evident with the patient erect, the arm forward flexed to the horizontal plane or abducted as far as

*Presented by courtesy of Dr. John A. Brooke, of Philadelphia.

possible, and the forearm extended and supinated. The weight of the forearm and hand is transmitted through the biceps and coracobrachialis muscles to the coracoid process and supraglenoidal tubercle, pulling the outer portion of the scapula downward and forward, while the vertebral border and superior internal angle are tilted upward, backward, and medialward by the levator scapulae and rhomboidei muscles. The disappearance of winging by the motion of flexion of the forearm is evidence that the biceps muscle, rather than the deltoid, is responsible for this deformity.

Secondary contraction of the biceps and coracobrachialis muscles in long-standing paralysis of their antagonist, the serratus anterior, must be overcome. This was demonstrated in Case 1 by (1) the complaint of the patient early in treatment of a "tearing sensation" in the elbow region near the biceps insertion, and (2) the fact that, early in the treatment, abduction above the horizontal plane was secured only with the elbow flexed about 150 degrees, but, following further recovery, abduction was restored with wider extension angles of the elbow joint.

The triceps muscle, antagonistic to biceps function, is the protagonist of the serratus anterior and, when the latter is paralyzed, becomes stretched. This becomes evident, as the serratus recovers and once more rotates the scapula, by (1) the relative weakness of extension of the elbow joint, and (2) the appearance of the triceps belly which hangs loosely when the arm is abducted 90 degrees and the elbow is fully extended.

Secondary stretching of the middle and lower portions of the trapezius, with pronounced shoulder drop, occurs early, as noted in all of our cases. Abduction to within the horizontal plane by the deltoid muscle is impaired by the absence of scapular fixation, and becomes further weakened by the secondary stretching of the posterior part of the deltoid.

TREATMENT

All exciting, contributing, and perpetuating factors—focal and systemic infection, intoxications, postural compression, occupation, and strenuous use of the affected extremity—must be treated or eliminated. The physiological balance of the shoulder must be restored by treatment with the recommended brace, physical therapy, massage, electrical stimulation (applied critically and accurately, so that only the paralyzed muscle and its stretched protagonists are stimulated), and guided exercises.

Loss of tonicity of the serratus anterior results in a medial, upward, and backward shift of the vertebral scapular border and its inferior angle, and a downward and forward displacement of the acromion process. It follows that, to relax a paralyzed serratus anterior muscle, the scapula must be *derotated*, and this is best accomplished by the apparatus illustrated in Figures 1-A, 1-B, 1-C, and 1-D. The adjustable elbow rest, made of celluloid or light metal, forces the humeral head upward and backward, and, through the latter's ligamentous attachments, the acromion, glenoid fossa, and coracoid process are also elevated. Full support is maintained through the pelvis alone, thus avoiding traction straps over

the shoulders. Slight external rotation of the arm, in addition to its backward thrust, may be necessary to approximate closely the scapula to the chest wall. The position advocated accomplishes the following:

1. It removes the weight of the extremity from the shoulder;

2. It derotates the scapula, relaxing the paralyzed serratus anterior and the stretched muscles and overcoming the contracted ones.

3. The effect of the biceps muscle on the scapula is eliminated by flexion of the elbow joint.

4. The pain of an associated bursitis or neuritis is relieved by immobilization.

Suspension of the arm by the wrist with a sling about the neck (Mackenzie), a direct pressure pad over the scapula (Thomson and Miles), the airplane brace (Fitchet), or plaster fixation with the arm abducted and externally rotated 90 degrees (Berkheiser and Shapiro), while they serve to relax the serratus anterior and to eliminate winging, fail to derotate the scapula properly and, thereby, to overcome the secondarily stretched and contracted muscles.

CONCLUSIONS

1. Anatomical studies indicate that the coracoid process of the scapula, the second rib, and certain related scapular bursae, as well as morphological variations in the formation and course of the long thoracic nerve, play significant rôles in the pathogenesis of localized paralysis of the serratus anterior muscle. Postural compression of the long thoracic nerve must be allowed a part as an exciting or perpetuating factor.

2. The biceps brachii, as a strong antagonist of the serratus anterior, is a leading factor in the production of the classic "winged scapula". The shoulder drop seen in cases of serratus-anterior paralysis, is a result of stretching of the middle and lower portions of the trapezius muscle, while weakening of abduction power is due in part to stretching of the posterior portion of the deltoid muscle.

3. Relaxation of the paralyzed serratus anterior muscle and correction of the associated stretched and contracted muscles are secured by eliminating both the winging and the abnormal rotation of the scapula, and this is effectively performed by the brace illustrated. This apparatus is also recommended in the treatment of brachial-plexus neuritis, and has been successfully employed in cases with cervical-rib or scalenus-anterior syndromes.

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TARSAL-WEDGE ARTHRODESIS

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Tarsal-wedge arthrodesis has been used in recent years to correct a variety of foot deformities. On the services with which the present author is associated, it has rapidly displaced several of the more extensive procedures heretofore considered standard in orthopaedic literature. Although no essential originality can be claimed for the operation, it has been developed and modified from its surgical forebears until at present it is a well-defined technique. Its advantages are relative simplicity, wide adaptability, and the excellence of the functional, as well as the cosmetic, result. It is physiologically rational.

TECHNIQUE

The operation is best performed under tourniquet. The author prefers two small incisions,—one longitudinal on the mid-dorsum, exposing the talonavicular joint; and a second on the lateral surface of the foot, exposing the calcaneocuboid articulation. (See Figure 1.) However, a single incision from below the external malleolus, running upward and forward to the mid-dorsal line about two fingerbreadths below the ankle joint, also gives adequate exposure. In both cases the exposed tendons are gently retracted, and the underlying membrane of the ligament, capsule, and periosteum is incised and elevated as a unit, bringing the articulation and adjacent bone into view. Next, a wedge-shaped piece of bone is marked out at the site indicated by the deformity. When an equinus deformity is to be corrected, the wedge is removed from both sides of the talonavicular joint, and includes the articulating surfaces. Thereafter the calcaneocuboid joint is denuded of its cartilage and placed in position for fusion. (See Figure 2.) When a varus deformity is to be corrected, the wedge is taken from the calcaneocuboid joint, with its base placed laterally, and a simple arthrodesis is performed at the talonavicular joint. It should be noted here that a wedge arthrodesis of one of these areas without arthrodesis of the other is not dependable. In several instances where this was tried, secondary deformity occurred. In the most common type of deformity, both equinus and varus deformities are present, and wedges must be removed from the talonavicular and calcaneocuboid articulations. It is not necessary to fuse the subtalar joint, since fusion of

FIG. 1

The two heavy lines show the incisions preferred by the author. The dotted line indicates the alternate single incision.

* Service of Samuel Kleinberg, M.D.

the two joints indicated accomplishes the same mechanical purpose in these cases.[2] If the equinus is marked and the wedge to be removed is necessarily large, it is preferable to take most of it from the navicular and to spare the head of the talus. The cosmetic result is better and it is equally effective. The foot is then brought into the corrected position by apposing the newly created denuded surfaces. The ligament, capsule, and periosteum are sewed with No. 2 chromicized catgut; the subcutaneous tissues, with No. 2 plain catgut; and the skin, with silk or dermol.

A plaster-of-Paris boot is applied from the toes to the knee with the foot held at a right angle to the leg and in slight adduction or abduction, depending upon the original deformity. During the application of the plaster, while it is still soft, the longitudinal arch is molded by hand. This gives a form to the arch which will be preserved more or less by subsequent fusion. An incidental advantage of tarsal-wedge arthrodesis is manifest at this point. The possibility that the foot may slip during the application of plaster is not as great a hazard as in certain other operations on the tarsus, since during the entire procedure the foot can be remolded by hand without reopening the wound. The importance of any single internal retention suture is minimal. The newly apposed bone surfaces are flat, and, if placed in position with reasonable accuracy, will overcome any slight diathesis during the process of fusion. The plaster is maintained for twelve weeks. It may be changed during that time, but it is best to leave the original plaster boot on for at least four weeks.

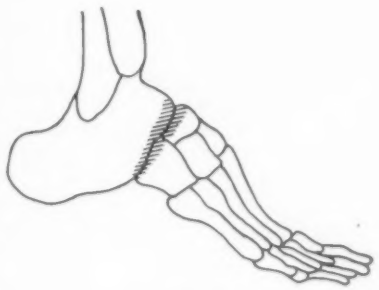

FIG. 2

The shaded area shows the simple design of the wedge and the arthrodesis.

PREOPERATIVE CARE

A factor which should be obvious, but too often is neglected, is that the less the extent of resection necessary to correct deformity, the more stable and more cosmetic the final result. To this end, the author recommends preliminary correction of marked deformity to an optimal position by non-traumatizing measures. For this purpose, the repeated plaster technique for the correction of severe club-foot, as described by Kite, has been found most suitable. Forcible correction by means of apparatus of the "wrench" type is to be deprecated. In cases where a marked cavus element accompanies a varus or equinus deformity, a preliminary release of the plantar fascia, according to the technique of Steindler, has considerably reduced the deformity and thereby minimized the necessity for extensive resection of the tarsal bones.

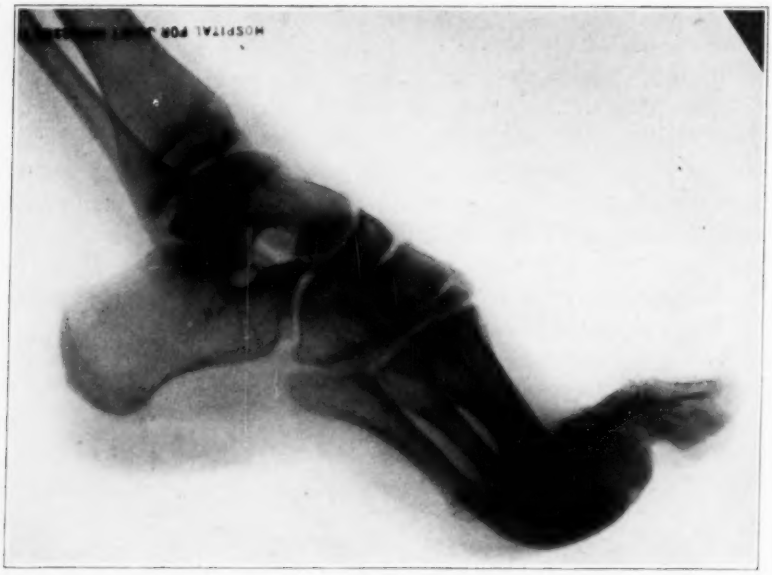

FIG. 3-A
V. L. Before operation.

INDICATIONS

Tarsal-wedge arthrodesis is indicated in a variety of foot deformities. In the present series of cases it has been used successfully for the following: equinovarus, varus, equinocavus, cavus, equinovalgus, and abduction of the forefoot (post-traumatic).

The pathology or, rather, pathogenesis of the deformity plays no part in determining the efficacy of the operation. The deformities of these feet are either congenital or the result of poliomyelitis, spastic paralysis, Friedreich's ataxia (cavus), suppuration, or fracture. The excellence or failure of the end result could in no statistical fashion be related to the cause of the deformity. The operation is designed to correct a static anatomical malposition of the tarsus.

CONTRA-INDICATIONS

Only two contra-indications are important. The first is imperative,—namely, the presence of an active lesion of the central nervous system. Tarsal-wedge arthrodesis should not be performed in such a case, since the subsequent progress of the disease leads to secondary deformity.

The second important contra-indication for tarsal-wedge arthrodesis is a very young patient. The minimal age at which tarsal arthrodesis is possible has been a moot question for years. In the present investigation, however, this has become secondary to a more pertinent observation. It is not a question of the age at which tarsal bones may be surgically fused, but at what age can arthrodesis be performed without subsequent secondary deformity of associated structures due to continued abnormal

Fig. 3-B
V. L. After operation.

growth of the foot. In a series of thirty-five cases of tarsal arthrodeses of various types in which adequate follow-up data were available, only two out of eight patients operated upon under the age of ten years could be said to have good results. In the other cases of this age group, secondary deformities supervened, requiring further correction. In the present series of fifteen tarsal-wedge arthrodeses, only three were performed on patients ten years or younger, because of the previous experiences noted. In one of these, the end result was good; in one, fair; in the other, bad. In general, tarsal arthrodesis in children ten years of age or younger must be considered undependable in spite of an occasional success.

END RESULTS

Of the fifteen patients operated upon and followed for a significant period of time (thirteen from one to five years and two for six months) good results were obtained in all but one. The one failure was a case of post-suppurative deformity in which insufficient correction was obtained because of preexisting fusions of associated joints in the foot, due to the original lesion. In one of the successful cases, a preceding tendon transplantation had been performed, which, in all fairness, had improved the function of the foot. It was further considerably improved by a tarsal-wedge arthrodesis. In two other cases, the operation, while correcting the deformity of the tarsus and function of the foot as a unit, did not correct preexisting "claw" toes. These were corrected by a subsequent operation.

In brief, when tarsal-wedge arthrodesis is performed in properly selected cases, it is found to be a mechanically sound procedure. Only one failure in fifteen cases is recorded, and that failure was due to an error in judgment for which the operation *per se* cannot be held at fault.

DISCUSSION

It has not been the author's purpose in this report to describe a new operation for deformities of the feet. He has reason to know that of these there are already more than enough. The object has been to urge the use of a procedure for which a simple standard technique has been developed and which has proved successful in a variety of foot deformities. The technique, which the author has termed the "tarsal-wedge arthrodesis", has the following advantages which entitle it to wide popularity:

1. It is simple to perform, and it allows for secondary improvement in position after closure of the wound.

2. It disturbs the internal architecture of the tarsus less than other operations requiring more extensive bone trauma. It, therefore, does not compromise the appearance of the foot to the same degree.

3. It has been almost uniformly successful in properly selected cases, and its indications include a number of the most common foot deformities. Hence it extends the adaptability of a simple procedure at the expense of a variety of more complicated ones.

The author wishes to thank Dr. Kleinberg, Dr. Selig, and Dr. Lippmann for permission to study cases on the Service, in which the operations were not performed by the author.

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HEMANGIOMATA OF THE LOWER EXTREMITIES

With Special Reference to Those of the Knee-Joint Capsule and the Phenomenon of Spontaneous Obliteration

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The primary occurrence of hemangiomata in practically all tissues and organs of the body except the hair and the nails has been reported. This paper is limited to a discussion of those hemangiomata arising from the deeper tissues of the leg and not those of cutaneous origin. These tumors are of interest because they occur more frequently and are more painful and disabling than those in other localities within the scope of orthopaedic surgery. Although often easily eradicated by surgery, they frequently cause years of suffering to the patient, due to lack of prompt recognition.

There is no sharply defined criterion as to the composition of hemangiomata. In this presentation, mainly cavernous hemangiomata are considered. These are tumors composed of large, irregularly shaped spaces filled with normal blood and separated by a connective-tissue septum. The blood spaces lack the definite walls of normal blood vessels, and may or may not have an endothelial lining (Fig. 1). Phleboliths are occasionally present. These tumors are frequently invasive, although benign in character. Metastatic hemangiomata have been reported (Hall, Jaffe, Markowitz, and Shennan) but this phenomenon is sometimes questioned.

The following five cases of hemangioma, which have come under the author's personal observation, are presented as typical of the condition.

Case 1. Cavernous hemangioma of the popliteal vein.

Clinical History: A man, aged twenty-seven years, was admitted to the University of Kansas Hospital on February 1, 1929. Ten years previously, and without apparent cause, soreness had been noticed in the left popliteal space. The pain had soon become sharp, although periodic in character, and gradually had become more intense. One year after onset the patient had begun to limp, and this had become more pronounced with time. Three weeks previous to admission a friend had "kneed" him in the left popliteal space. The patient had had immediate terrific pain in the area of the blow, causing him to fall to the floor, from which he had been unable to rise. He was carried home where a physician administered a hypodermic of one-fourth of a grain of morphine sulphate, with little if any effect upon the pain. At the end of about twelve hours, the pain had begun to subside, and after three days the patient attempted to return to work. However, he was so uncomfortable that he reported to the Hospital for aid.

Examination: The left leg showed moderate atrophy of the thigh and the calf. The knee lacked about 15 degrees of complete extension. A soft nodular tumor, about the size of a hazel nut, exquisitely tender to pressure, was palpated in the outer half of the popliteal space. The skin was freely movable over the mass and was not discolored. There was no pulsation.

Operation: On February 5, 1929, an operation was performed by the author, and a

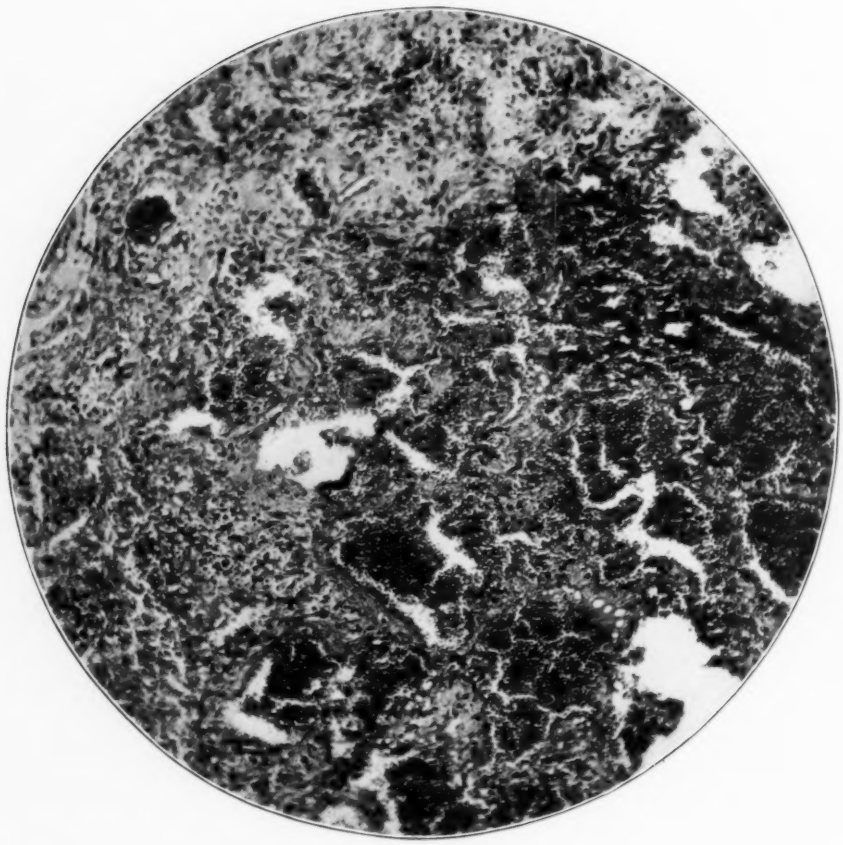

FIG. 1

Photomicrograph of histological section of hemangioma (Case 2).

soft, bluish, lobulated tumor was found, which was adherent to the surrounding tissues. The tibial nerve was incorporated in the tumor and was pushed to the outer side of the popliteal space. After the mass was dissected free, it was found to be attached to the popliteal vein by a short vessel. The "stem" was ligated, and the mass was removed.

Postoperative History: One month after operation the patient was symptom-free, and there was no tenderness in the popliteal space.

Histological Report: "The wall of a large dilated vein is seen, in which there is marked thickening of the intima. In some places the vessel wall is broken down and surrounded by a rather vascular and cellular wall resembling cellular granulation tissue. There are no leukocytes, but many fibroblasts and young capillaries are seen. Other portions are typical of the blood spaces of a cavernous angioma."

CASE 2. Cavernous hemangioma of the capsule of the knee joint.

Clinical History: A girl, aged fifteen years, was admitted to the University of Kansas Hospital on May 6, 1929. At the age of five years she had fallen, striking the right knee on a "foot scraper". This had caused a slight laceration over the area of the anterior and inferior border of the medial condyle of the femur, which had healed promptly, but this area had been exceedingly sensitive to a blow or pressure ever since. The patient had had frequent "attacks" of pain in the knee, which had lasted from a few minutes to several weeks, usually occurring after a blow on the knee, or when arising from a sitting

posture. The knee had frequently "given way" although locking had never occurred. At the age of eleven years, the right leg had been encased in a plaster-of-Paris bandage for a period of four months, which had given relief from pain while it was worn and for several months thereafter. Three months previous to admission the patient had had scarlet fever and immediately thereafter the knee became so painful that she was unable to attend school.

Examination: The right leg was three-fourths of an inch shorter than the left, and the right thigh presented two and three-fourths inches of atrophy, and the right calf one and one-fourth inches of atrophy. Active motion at the knee joint was moderately painful, with restriction of extension. There was marked tenderness on pressure throughout a small area over the lower border and anterior aspect of the medial condyle of the femur. There was no palpable tumor.

Operation: On May 7, 1929, an operation was performed by Dr. C. B. Francisco, and a small mass of fibrous tissue and dilated veins (thirty by twenty by ten millimeters) was found lying on and attached to the capsule of the knee joint, at the area of tenderness. This mass was excised without opening the capsule.

Postoperative History: A letter, dated April 5, 1933, stated that the patient had been symptom-free since the operation, but she still had the same amount of shortening although much less atrophy of the thigh and the calf.

Histological Report: "A typical picture of a cavernous hemangioma."

CASE 3. Cavernous hemangioma of the extensor digitorum brevis muscle.

Clinical History: A girl, aged ten years, was admitted to the University of Kansas Hospital on February 23, 1931. Five years previously a flatiron had been dropped upon the dorsum of the patient's right foot. There had been considerable oedema, ecchymosis, and pain immediately following, all of which had disappeared in about ten days. A small subcutaneous nodule had remained at the site of injury. There had been no further symptoms until three years later, when the small tumor had become sensitive to pressure. Since the onset of tenderness, the tumor had gradually increased in size. It was exceedingly painful if struck and had become so sensitive to pressure that a shoe could not be worn.

Examination: There was no atrophy of the thigh or the calf, and no limited or painful motion was noted at any of the joints. There was a small, elongated, easily compressible, and exceedingly tender tumor on the dorsolateral aspect of the right foot. The skin over the tumor had a bluish tinge, but was freely movable.

Operation: On February 25, 1931, an operation was performed by Dr. C. B. Francisco. A small bulging mass of blood vessels was found in the extensor digitorum brevis muscle. The tumor, with a portion of the muscle, was excised.

Postoperative History: On February 29, 1933, the patient was readmitted to the hospital with a recurrence of the tumor. The tumor was excised more widely this time, but two years later there was another recurrence and a third excision was done elsewhere. The patient was symptom-free on January 1, 1937.

Histological Report: "A typical picture of a cavernous hemangioma."

CASE 4. Cavernous hemangioma of the vastus lateralis muscle.

Clinical History: A man, aged twenty years, was seen at the University of Kansas Hospital on January 18, 1933. He complained of pain and weakness in the left leg, which had been present ever since he had had diphtheria at the age of twelve years. Since the onset there had been a small area of tenderness on the lateral surface of the thigh just above the knee. Even the lightest of blows on the tender area caused excruciating pain, the patient almost passing into a condition of shock. For six months previous to admission, he had been unable to walk more than one or two blocks at a time because of pain and weakness in the leg.

Examination: There was atrophy of the left thigh amounting to two and one-half inches and atrophy of the left calf amounting to two inches. (See Figure 2.) The hip, knee, and ankle joints presented no limitation of motion. There was a small subcuta-

neous nodule palpable just above the lateral condyle of the knee. The skin was not attached to the tumor, which was so tender to palpation that nothing further could be determined by touch. Roentgenographic examination of the area was negative.

Operation: On January 23, 1933, an operation was performed by the author, and a small mass of veins about the size of a pea was found imbedded in the vastus lateralis muscle and excised.

Postoperative History: In a few weeks' time the patient was working on a farm. On June 15, 1936, he stated that he had remained entirely symptom-free and that his legs were practically the same size.

Histological Report: "A typical cavernous hemangioma with considerable lipomatosis and inflammatory reaction."

CASE 5. Obliterated hemangioma of vastus lateralis muscle, with phlebolith.

Clinical History: A girl, thirteen years old, was admitted to the University of Kansas Hospital on April 28, 1928, complaining of an extremely sensitive area on the lateral surface of the left knee. Six or seven years before admission she had frequently complained of pain in the left knee after a day of hard play. There had been no further complaints until three years later, when a left limp had developed and the patient had begun to complain, if touched or struck on the outer surface of the left knee. The limp had persisted and the tenderness had increased. She ran and played, but screamed with pain from the lightest of blows upon the outer surface of the left knee.

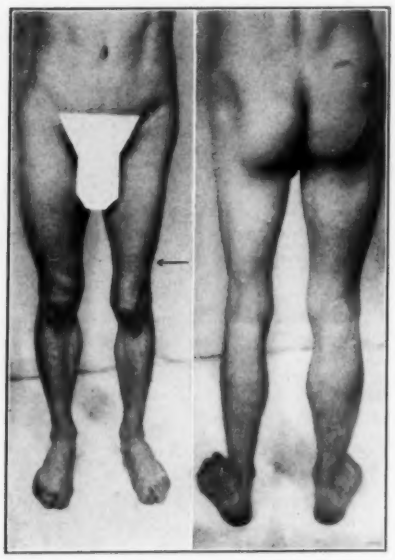

FIG. 2

Photograph of patient in Case 4 showing marked atrophy of the left leg. The arrow indicates the location of the tumor.

Examination: The left leg presented atrophy of one and one-quarter inches in both the thigh and the calf. Extension at the knee was limited to 160 degrees and flexion to 85 degrees. Motion at the knee was not painful. Roentgenograms showed a calcified nodule about the size and shape of a small pea, situated at the side of the lateral condyle and in the soft tissues.

Operation: On April 29, 1928, an operation was performed by Dr. C. B. Francisco. Deep in the vastus lateralis muscle was found a calcareous deposit in a mass of small threadlike tendrils. The mass was excised.

Postoperative History: On March 24, 1935, her family physician reported: "She has had no recurrence and no pain. Motion is perfect."

Histological Report: "Section shows several masses of hyaline fibrous tissue markedly infiltrated with mononuclear leukocytes. Embedded in these leukocytic foci are peculiar dark-blue-staining bodies suggesting typical calcareous masses. Some multinucleated giant cells are seen around these. There is considerable fat tissue and at one side are a few small blood spaces separated by hyaline fibrous tissue."

In the foregoing cases striated muscle is involved three times, the capsule of the knee joint and the popliteal vein once each.

The literature in regard to hemangiomata of striated muscle has been reviewed in two excellent papers. In 1929 Davis and Kitlowski reported 201 cases, and added eleven new cases. Six of these had been

previously reported by Davis. In 1932 Jenkins and Delaney again reviewed the literature, excluded eighteen cases reported by Davis and Kitlowski, found sixty-one others, and added one of their own,—a total of 256. The distribution of these lesions was as follows: lower extremity, 107; upper extremity, sixty-four; head, neck, and trunk, eighty-four; and one unclassified.

Since the cases in this report are not confined to striated muscle, a search of the literature was made to ascertain the frequency of occurrence in other tissues of the leg. The case reports so found, excluding those in this paper, total thirty-three as summarized in Table I. With the addition of 104 * cases of hemangioma of striated muscle previously mentioned and the five cases reported in this paper, there is a grand total of 142. Undoubtedly some reports have escaped the author's attention, and unquestionably many cases have not been reported or have not been recognized, so it seems reasonable to assume that the condition is not rare, and is probably of more frequent occurrence than is generally realized.

The distribution of hemangiomata in various tissues of the leg in these 142 cases is indicated in Table II. The part primarily involved is recorded as definitely as possible, although in some instances this was impossible, as several structures were involved by the one process. The relative frequency with which the capsule of the knee joint is involved is quite striking when one compares the bulk of this structure to that of the muscles of the leg. The explanation of this phenomenon, in the author's opinion, is found in the rich blood supply of the capsule plus its liability to trauma.

In Figure 3 the regional distribution is indicated. The data concerning the buttocks and the foot are exact, while those of other areas are approximate. In many instances the lesion overlapped the arbitrarily defined areas, while in others the exact location was not clear from the case reports. The figures are considered to be correct within the limit of 10 per cent. of error. It is of interest that a large percentage of tumors occur in rather close proximity to the knee joint.

The etiology of hemangiomata is unknown. Most authors accept the theory of a congenital anomaly, with trauma frequently playing a rôle in the development of the tumor and its symptoms. This is no doubt correct in many cases, yet there is much evidence that the principal etiological factor in a moderate number of cases is injury. This fact has been emphasized by Mailer, who reported a case of traumatic hemangioma of muscle. In support of the congenital theory is the unassailable fact that some of these tumors are present at birth. Additional evidence brought forward is that 80 per cent. of hemangiomata make their appearance before the twenty-first year and that they are found in tissues not readily

* Three cases, operated upon by Eve, reported by Hilgenberg, and summarized by Davis and Kitlowski as arising in muscle, are considered by us to have arisen in the knee-joint capsule (synovia) and are so listed in Table I. Thus there are 104 cases of hemangiomata arising in muscle, instead of 107 as previously mentioned.

TABLE I

SUMMARY OF THIRTY-THREE CASES OF HEMANGIOMA OF THE LEG

Case No.	Author and (Surgeon)	Sex	Age (*Years*)	History	Clinical Findings	Operative Findings and Result	Pathology
				CAPSULE OF THE KNEE JOINT			
1	E. S. Bastos	Male	39	Difference in size of knees noted since birth. At age of 10, right knee became painful after running a race. Size of knee and severity of pain increased with time.	Knee joint contained bloody fluid. A spongy, compressible tumor the size of an orange was palpated. Pressure evoked intense pain.	Tumor arising from capsule. Excision. Partial synovectomy. Recovery.	Typical cavernous hemangioma.
2	R. Bertelsmann	Female	27	Pain in knee at age of 15, with remissions. At age of 22, knee became so painful from blow and use that patient could not bear weight.	No hydrops. Flexion of knee or light pressure to inner border of patella produced severe pain and caused patient to cry out.	Small tumor embedded in thickened capsule. Excision. Recovery.	Hemangioma with round-cell infiltration and areas of chronic inflammation.
3	E. Bouchut	Female	3	Undernourished child.	Soft elastic tumor on inner aspect of knee. Skin normal. Aspiration yielded blood.	Patient died of "exhausting diarrhoea". Autopsy revealed angioma of capsule, extending into knee joint.	Resembled tissue of corpus cavernosum or sponge filled with blood. No microscopic examination.
4	Oswald Duda	Male	18	Pain and stiffness in left knee 4 weeks previous to observation.	Tumor size of pigeon's egg at outer margin of patella. No functional impairment.	Tumor arising from inner capsule (synovia). Excision.	Cavernous hemangioma. Phleboliths.
5	H. Eggers	Female	18	In 1914, 1918, and 1923, patient reported with hydrops. Plaster casts and hot-air treatment gave relief. Aspiration in 1923 yielded blood. In 1927 small, painful tumor found at puncture site. No other injury.	Atrophy of quadriceps and limited motion of knee joint. Tumor size of small saucer in upper outer quadrant of knee. Pain disappeared on elevation of foot. Area tender.	Tumor on outer capsule. Excision revealed another tumor size of dollar on inner surface of capsule. Two tumors were connected. Recovery.	Cavernous hemangioma. No histological examination.

6	Alfred Haas	Male	30	Pain and swelling of right knee at age of 5. Treated to tenth year by casts, with remissions. Remission until seventeenth year, when there was marked hydrops with pain. Marked pain and swelling on slight trauma or use.	Hydrops of right knee. Slight flexion contracture. Flexion painful. No circumscribed tumor. Varicosities in popliteal space.	Tumor mass filled joint and covered entire synovia and cartilage. Synovectomy. Well for 2 years; then recurrence. At age of 30 patient requested relief at any price. Excision of knee joint. Angiomatous masses extended into head of tibia.	Capillary hemangioma of synovial membrane.
7	Alfred Haas	Female	22	From birth, several small red tumors present just below popliteal space. Ten years previous to examination, a small tumor had been noted just above patella. Was painful on kneeling. Excised 5 years later. Recurred and became very painful.	Atrophy of left thigh. No hydrops. Small, very tender, and freely movable mass just above patella. Several bean-sized cutaneous angiomata present.	A tumor the size of a pigeon's egg invaginating the inner surface of the capsule. Partial synovectomy. Recovery.	Considerable fat and fibrous tissue surrounding a cavernous hemangioma.
8	F. C. Hilgenberg (Eve)		15	Swelling size of pea on outer portion of knee. Gradually increased in size to that of a hen's egg. Later, great pain. No apparent cause.		Angioma beginning in synovial membrane. Excision. Recovery.	Cavernous hemangioma.
9	F. C. Hilgenberg (Eve)		10	Pain in left knee of 4 to 5 years' duration, without apparent cause. Increase of pain and disability.	Oedema of inner border of patella. Increased heat after exercise. Skin normal.	Small tumor on inner surface of synovial membrane. Excision. Recovery.	Cavernous hemangioma.
10	F. C. Hilgenberg (Eve)	Female		Young woman with history similar to that of Case 8.		Angioma of upper recesses of synovial membrane, extending into surrounding muscles. Excision. End result unknown.	Cavernous hemangioma.

TABLE I (*Continued*)
SUMMARY OF THIRTY-THREE CASES OF HEMANGIOMA OF THE LEG

Case No.	Author and (Surgeon)	Sex	Age (*Years*)	History	Clinical Findings	Operative Findings and Result	Pathology
11	F. C. Hilgenberg (Seidener)	Male	37	Injured knee in fall 2 years previously. Pain and oedema after 2 years. Oedema would appear suddenly and remain 8 to 14 days. Patient unable to walk at time of examination.	Oedema of knee. Tumor size of hen's egg between head of fibula and tuberosity of tibia. Skin and joint motion normal. Aspiration yielded blood.	Extrafascial tumor excised and a second tumor found on inner surface of synovial membrane. This tumor also excised. Patient able to work, but motion of knee joint limited.	First tumor, fibrolipoma. Second tumor, pigmented hemangioma of joint capsule.
12	F. C. Hilgenberg (Zesas)		25	Pain in knee for 1 year. No trauma. Recurrent swelling. Patient never entirely free from pain.	Slight contracture of knee. Motion painful. Slight amount of fluid. A small, soft tumor on inner side of patella, disappearing on pressure.	Extensive tumor continuous over joint capsule with processes branching into muscle. Partial synovectomy. Recovery with fair motion.	Cavernous hemangioma.
13	F. C. Hilgenberg (Oeser)	Male	33	Since youth, periodic painful swelling of right knee, without cause. Usually appeared a few minutes after slight trauma. Greatest pain on walking.	Fluctuant swelling almost the size of a hen's egg on the inner side of knee above patella. Muscles atrophic. Motion free.	Tumor removed from inner side of joint capsule. Patient free from pain after operation. Almost complete motion.	Cavernous hemangioma combined with a papilloma.
14	F. C. Hilgenberg (Müller)		17	Pain in right knee for 2 years.	Region of inner epicondyle somewhat swollen and tender.	Tumor size of pea on medial aspect of joint capsule. Excision. Recovery.	Hemangioma.
15	F. C. Hilgenberg (Marburg Surgical Clinic)	Male	19	At age of 13, knee injured. After bed rest, patient ambulatory with occasional pain and limitation of motion. Knee again injured at age of 18. Swelling and pain increased until patient was unable to walk.	Tumor size of hen's egg on inferior and outer border of patella; fluctuant and very tender. Motion restricted and painful.	Tumor size of walnut growing through joint capsule. Cavernous process invading joint. Partial synovectomy. Recovery.	Cavernous hemangioma.

16	G. B. Lauwers	Male	30	One year previously, while climbing a ladder, patient had slipped, striking knee. Painful for 2 years; then worse. Could walk only 1½ hours daily. Some days bedridden.	Some hydrops. Motion of knee limited and painful. Atrophy of thigh and calf. Very tender spot, 3 by 4 centimeters, in upper outer quadrant of knee.	Small tumor beneath fascia and in the capsule. Excision. Recovery.	Angiofibroma.
17	J. T. O'Ferrall	Male	19	Slight injury to right knee joint 5½ years previously. Slight swelling and pain. Localized swelling on outer border of knee cap for 2 years. Mass very tender. Slight trauma caused such severe pain patient could hardly walk.	Mass over external aspect of knee size and shape of terminal phalanx of thumb. Very tender. Atrophy of thigh and calf. Full extension. Flexion limited.	Mass in anterior chamber of knee, arising from synovial membrane at head of tibia, excised with portion of joint capsule. Limp after 16 months, with 25 degrees of flexion. No recurrence.	Cavernous hemangioma.
18	J. T. O'Ferrall (G. A. Caldwell)	Female	20	At age of 2 years, patient fell, striking right knee which became swollen and tender. At age of 8, right knee struck with baseball bat. Patient was unable to walk for several months. Slight to severe pain persisted. At age of 16, patient became entirely disabled.	Extension complete but painful. Flexion limited to 90 degrees. No hydrops. Mass over outer margin of patella and extending to lower third of thigh. Mass markedly tender. X-ray negative.	Mass of small veins arising from joint reflections and extending under quadriceps. Small section removed. Second operation revealed a mass from epiphyseal line of femur to junction of middle and lower thirds of thigh. Ten months later, no recurrence.	Hemangioma.
19	Reichel and C. Nauwerck	Male	18	Pain and swelling of right knee at age of 16. No apparent cause. Patient in bed 8 weeks at onset; then worked up to 1 month before entering hospital.	Knee swollen. Motion slightly restricted. Serous fluid obtained on aspiration. Later, tumor size of pigeon's egg noted on inner border of patella. Not painful on pressure.	Tumor found embedded in synovia. Partial synovectomy. Knee remained slightly restricted in motion.	Cavernous hemangioma.

TABLE I (*Continued*)

SUMMARY OF THIRTY-THREE CASES OF HEMANGIOMA OF THE LEG

Case No.	Author and (Surgeon)	Sex	Age (*Years*)	History	Clinical Findings	Operative Findings and Result	Pathology
20	E. Venezian	Male	3	Nine months previously, patient fell and bruised knee. A small tumor appeared. This was quiescent for a time; then patient suffered sudden severe pain and oedema. Slight trauma aggravated the condition.	Knee flexed. Small mass just above head of fibula. Pressure on tumor elicited pain. Exploratory puncture yielded blood.	Angioma of synovia, extending to infrapatellar fat pad. Partial synovectomy. Knee remained slightly restricted in motion.	Cavernous angioma with considerable fat tissue.
				TENDON			
21	M. S. Burman and J. E. Milgram (A. Steindler)	Male		Pain in left knee of 6 years' duration. Mild trauma 2 years previous to onset of symptoms.	Extremely sensitive area just above patella at outer border of quadriceps. Atrophy of thigh. X-ray showed loose bodies in knee joint.	Cirsoid mass external to synovia and arising from quadriceps tendon. Resection of tumor and adjacent tissue. Second operation 3½ years later because of pain. No recurrence. Adhesions freed with care.	Cavernous hemangioma.
22	M. S. Burman and J. E. Milgram (M. S. Burman)	Female	7	Lump on outer side of left leg of 4 years' duration. No increase in size. Lump caused increase in limp already present as result of infantile paralysis.	Tumor, 5 by 4 by 4 centimeters, on lateral aspect of leg 5 inches above ankle. Skin normal.	Angiomatous mass interrupting course of peroneocuboideus tendon. Excision. No recurrence or symptoms 6 months later.	Cavernous hemangioma with no evidence of tendon in center of tumor.
23	M. S. Burman and J. E. Milgram (Miltner)	Female	22	Lump in left popliteal space of 17 months' duration, preceded by general joint pains. Mass fluctuated in size and caused some discomfort.	Tumor size of walnut tender to pressure.	Tumor originating from semitendinosus tendon and attached by a pedicle. Excision. Patient symptom-free 6 months later.	Encapsulated cavernous hemangioma containing much hyalinized fibrous tissue.
24	M. S. Burman and J. E. Milgram (Wilkie)	Female	26	Tumor size of lemon present for 2 years. No pain.	No note.	Mass removed from tendon of plantaris.	Cavernous hemangioma.

				NERVE			
25	F. H. Purcell and E. S. Gurdjian	Female	1¾	Tenderness of left buttock at 8 months. At 16 months, plaster hip spica applied because of limp and increasing pain. Cast worn 6 weeks. Improvement for 4 months; then pain recurred.	Fullness of left buttock. Atrophy of thigh and calf. Bandlike resistance at level of trochanter and ischial tuberosity. Tenderness in buttocks.	Dark blue tissue invading sciatic nerve for a distance of 2 inches. Removed. Recovery.	Cavernous hemangioma.
26	F. H. Purcell and E. S. Gurdjian (Schutze)				Marked tenderness and swelling along course of posterior tibial nerve at ankle.		Hemangioma.
27	René Sommer (Leusden)	Female	5	Tumor first noticed as swelling on left heel. No hindrance on running or walking. A few days before patient was seen, tumor became painful to touch.	A very tender tumor deep in tissue over os calcis and between medial malleolus and tendo achillis. Motion of foot and ankle complete and painless.	Tumor about the thickness of the index finger attached to posterior tibial nerve. Shelled out easily.	Encapsulated cavernous hemangioma.
28	S. F. Stewart and M. E. Bettin	Male	10	Lump seen in right lower leg at 10 months. Later, 3 other lumps noted. At 4½ years, increase in size of tumor and in severity of pain. Patient excluded from school because of pain and deformity.	Right knee flexed at 90 degrees. Hip flexed and foot in equinovalgus. Atrophy of foot. Lower belly of gastrocnemius muscle enlarged and also upper part of tendo achillis. Tender to palpation.	Large hemangioma of internal popliteal nerve with multiple angiomata of other branches of sciatic nerve. Amputation above knee.	Hemangioma.
				BONE			
29	Rudolf Pohl	Female	56	At 53, Pirogoff amputation for "creeping disease" of foot performed. Pain persisted. Three nerve operations performed, with no relief. Proliferation on mid-shin very painful and tender.	Palpable elevation on tibia size of apple. Sharply localized tumor of bone—loss of calcium surrounded by sclerosis.	Amputation at knee.	Cavernous hemangioma.

TABLE I (*Continued*)

SUMMARY OF THIRTY-THREE CASES OF HEMANGIOMA OF THE LEG

Case No.	Author and (Surgeon)	Sex	Age (*Years*)	History	Clinical Findings	Operative Findings and Result	Pathology
30	M. Van Neck	Female	56	In 1927, patient began to have pain in left knee and thigh. In April 1928, pain localized in patella.	No atrophy. No pain on motion. Area painful to pressure. X-ray showed area of destruction size of pea in patella.	Curettement. Immediate relief from pain.	Hemangioma.
				VEIN			
31	Samuel Kleinberg	Male	7	Swelling of calf of right leg noticed at age of 3 weeks. Gradual increase in size. No symptoms or disability.	Tumor size of orange in right calf superficial to muscle and not attached to skin. No pulsation. Not sensitive to pressure.	Pear-shaped mass,—body above, stem below. Terminated in single vein. Above, tumor continuous with small vein. Excision. Recovery.	Cavernous hemangioma.
				INFRAPATELLAR FAT PAD			
32	J. T. O'Ferrall (R. B. Osgood)	Female	24	At age of 5, injured right knee. Ever since, patient had limped slightly and had favored knee. At 21 years, moderate pain was present. Any slight blow caused pain.	Atrophy of calf and thigh. Slight flexion. No hydrops. Some puffiness beneath patella; this area very tender.	Tumor size of 25-cent piece with small tablike lobe, arising from infrapatellar fat pad. Excision. Recovery.	Cavernous hemangioma.
				PREPATELLAR BURSA			
33	Oswald Duda (Von Ranka)	Female	24	Tumor supposed to have followed prepatellar bursitis.		Hemangioma found on floor of prepatellar bursa. Excision.	Cavernous hemangioma.

subjected to injury. Since nevi are almost always congenital in origin, association of ideas makes the congenital theory readily acceptable when viewed in conjunction with the foregoing evidence. On the other hand, many of these cases present a clear-cut history of injury followed in a reasonable length of time by the appearance of the tumor, or the symptoms of the same, at the site of trauma. A moderate number appear in middle-aged and elderly patients. It must be remembered that the growth period is the age of most frequent injury, and, as far as the cases in this presentation are concerned, hemangiomata occur in those areas most frequently subjected to injury (Fig. 3). Of the 142 cases in this series, nineteen, or 13.4 per cent., are definitely congenital in origin. In thirty, or 21.1 per cent., there is a definite history of injury followed by the formation of a hemangioma at the site of trauma. In six cases, or 4.2 per cent., there is a history of external injury influencing the course of an existent hemangioma. Of the remaining cases, in twenty-three, or 16.2 per cent., there is a definite statement of no injury; while in sixty-four, or 45.1 per cent., no data were given on this point. It does not seem beyond reason that some error in growth may occur, with the formation of a hemangioma, in the production of new blood vessels in the repair of traumatized tissue. This might be especially true in the presence of a hematoma, according to the theory of Pilzer. Certainly, "traumatic" is a far more applicable descriptive prefix than "congenital" in reference to the author's Cases 2 and 3 of this series and to similar cases.

FIG. 3

Regional distribution of hemangiomata in the lower extremity.

Regardless of its rôle as an etiological factor, trauma undoubtedly plays an exceedingly important part in the development of the symptoms of these neoplasms. Trauma may be either internal or external in type, or a combination of the two. Internal trauma is produced by the stress and strain about a weight-bearing joint as well as by muscle relaxation and contraction. This observation is verified by the fact that angiomata occurring about weight-bearing joints are more painful and disabling than those located about non-weight-bearing joints or those situated remotely from a joint (Table III). It is further confirmed by the fact that bed rest relieves pain, and immobilization of the part in a plaster-of-Paris bandage relieves pain not only during the period that the bandage is worn, but also for several weeks or months after its removal (this series: Eggers, Haas, O'Ferrall, Purcell and Gurdjian, and the author's Case 2). Fürnau's patient (case reported by Davis and Kitlowski) had no pain at night, but the application of a cast was followed by severe pain. A cast causing pressure on a hemangioma would undoubtedly produce an increase in the amount of pain, and from the history one suspects such was the case in

TABLE II

DISTRIBUTION OF HEMANGIOMATA IN THE LEG

Structures Involved	No. of Cases	Total Cases
Skeletal muscles:		
Quadriceps femoris	21	
Gastrocnemius	17	
Vastus medialis	15	
Biceps femoris	10	
Vastus lateralis	7	
Semimembranosus	6	
Glutei	6	
Soleus	5	
Gracilis	2	
Semitendinosus	2	
Miscellaneous and unclassified	16	107
Capsule of knee joint	21	21
Tendons:		
Quadriceps femoris	1	
Peroneocuboideus	1	
Semitendinosus	1	
Plantaris	1	4
Nerves:		
Sciatic	2	
Posterior tibial	2	4
Bones:		
Patella	1	
Tibia	1	2
Veins:		
Branch from popliteal	1	
Vein of calf	1	2
Infrapatellar fat pad	1	1
Prepatellar bursa	1	1
Total		142

this instance. In numerous cases the tumor gave no symptoms for months or years, but became painful after some major injury or series of minor injuries or after some form of severe physical exercise, such as a foot race (this series: Bastos), jumping (Jenkins and Delaney's series: von Khautz) or dancing (Davis and Kitlowski's Case 10). With rest, the pain disappears to become recurrent upon repeated and less vigorous external trauma or exercise until it eventually becomes so severe that the patient is partially or totally disabled.

Trauma does not necessarily affect the rate of growth of these neoplasms. A hemangioma may pass from the quiescent to the acutely painful stage and an increase in size may or may not follow. As a matter of fact, some of these tumors do not increase in size from the time when they are first noticed through a period of several years.

A lesser factor in the etiology and symptomatology of hemangiomata is disease. In two instances there was an increase in symptoms following scarlet fever (Davis and Kitlowski's Case 2 and the author's Case 2). The tumor was first noticed following diphtheria (the author's Case 4), prepatellar bursitis (this series: Von Ranka), grippe (Davis and Kitlowski's series: Guyot and Jeanneney, and Bénard and Lamy), and appendicitis (Davis and Kitlowski's Case 6). While this phenomenon is rare, it has occurred frequently enough to merit consideration if not emphasis.

The cardinal symptom is pain. This observation has been made by most authors. Davis and Kitlowski, who have had the richest clinical experience, consider pain the chief symptom. Bénard and Lamy believe that the word "*douloureux*" should be added to the name of these tumors. Sommer stated that, due to pain, many of these patients have the appearance of patients suffering from pulmonary tuberculosis. In Kirmisson's case (Davis and Kitlowski's series) a general anaesthetic was required before the tumor could be palpated. Some authors who report a case of non-painful hemangioma do not stress this point. Jenkins and Delaney are frequently quoted as stating that pain was present in 58 per cent. of their cases. This statement is true, but does not tell the complete story and is, therefore, misleading. It would have been equally correct, but also misleading, to state that no pain was present in only 12 per cent. of the cases in the series reported by these authors. As a matter of fact, there was a definite history of pain in 56 per cent. of the cases and of no pain in 12 per cent. There was no statement concerning this point in the remaining 32 per cent. Since many of the cases were reported by non-clinicians and only a meager clinical history, or no clinical history, was given, it does not seem correct to assume that pain was not present in all instances unless a definite statement was made to the contrary. The author knows of no other small benign tumor of a non-vital tissue such as synovia or muscle which can be so excruciatingly painful and completely disabling as a hemangioma. A possible exception is the glomus tumor or arterial angioneuromyoma of Masson, and these neoplasms are a type of hemangioma.

Various theories are advanced as to the mechanism of the production of pain. Spontaneous pain is accepted as the explanation by some authors. Many hemangiomata, especially congenital ones, are symptom-free in the beginning and remain so for several months and as long as sixty years before becoming painful. Certainly spontaneous pain can be ruled out in these cases. Angiolithic concretions are said to cause pain. Any irritative or congestive factor probably does cause pain, but in only a small percentage of hemangiomata are phleboliths present.

TABLE III

STATISTICS IN REGARD TO PAIN

Series	Lower Extremity						Upper Extremity						Head, Neck, and Trunk					
	Pain		No Pain		No Statement		Pain		No Pain		No Statement		Pain		No Pain		No Statement	
	No.	*Per Cent.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*
Davis and Kitlowski (190 cases *)	51	61.5	5	6.0	27	32.5	13	28.2	9	19.6	24	52.2	27	44.3	5	8.2	29	47.5
Jenkins and Delaney (62 cases **)	16	76.2	2	9.5	3	14.3	11	61.1	1	5.6	6	33.3	11	47.8	5	21.8	7	30.4
Weaver (38 cases)	33	86.8	2	5.3	3	7.9												
Total	100	70.4	9	6.4	33	23.2	24	37.5	10	15.6	30	46.9	38	45.2	10	11.9	36	42.9

* From the original series of 212 cases reported by these authors, Jenkins and Delaney deleted eighteen cases; the present author removed three; and one case was unclassified as to location and was, therefore, omitted.

** Not included in the series of Davis and Kitlowski.

Pressure on a nerve is said to be a factor. This may be true. There was demonstrable nerve pressure in only a few instances, as in Case 1, but not all of these patients had pain. In addition, as previously mentioned, many hemangiomata change from the quiescent to the painful stage with no alteration in size. The location of the tumor as regards its liability to trauma is apparently of far greater importance in the production of pain than the type of tissue affected.

The following opinion is deduced from the foregoing evidence. Hemangiomata in themselves are not painful, but at some period they become painful as the result of irritation, congestion, or inflammation of the tumor, caused by one or a combination of the following factors, mentioned in the order of their importance: internal or external trauma, as previously defined; increased internal pressure, due to growth of the tumor and resistance of the surrounding tissues; phleboliths; or absorption of toxins from a disease process. In addition, injury to surrounding tissues, due to growth of the tumor, undoubtedly causes pain in some instances.

The objective symptoms, like the subjective ones, vary somewhat with the location of the tumor and its liability to injury. These findings, as far as angiomata of muscle are concerned, have appeared in print so frequently that reiteration here is deemed unnecessary.

Angiomata of the knee-joint capsule present uniformly more severe symptoms due to joint involvement. Pain is the most constant symptom and was present in twenty of the twenty-one* cases reported. This pain was so severe as to be totally disabling in ten cases and at least partially disabling in the other 50 per cent. There is usually marked atrophy of thigh and calf muscles and in some instances shortening of the leg. Flexion contracture of the knee with limitation of motion is common. Motion is usually painful. Hydrops of the joint was of frequent occurrence. If a tumor is palpable, it is soft and compressible and usually extremely tender to pressure. Elevation of the leg may reduce the size of the tumor. There is capsular thickening. Aspiration of the tumor produces blood. The skin is normal. In some instances roentgenograms reveal the presence of phleboliths. A patient presenting the majority of these signs and symptoms is entitled to an exploratory arthrotomy.

Davis and Hertzler mention that hemangiomata at times undergo spontaneous cure. Traub states that capillary and cavernous hemangiomata have been definitely observed to disappear spontaneously in a number of cases, the latter much more rarely, however, than the former. Case 5 is considered to be an example of spontaneous obliteration of a cavernous hemangioma. This supposition is based on the following data. The patient was of the correct age, and pain first made its appearance after exercise. There was a three-year period of no symptoms, indicative of a change in the pathological process. The site is a favored one for

* An additional case, reported by Mizuno, has been noted since this series was compiled.

hemangiomata. The roentgenogram revealed a phlebolith consisting of concentric rings, which, according to Davis and Kitlowski and also to Watson-Jones and Roberts, are pathognomonic of a phlebolith occurring in a hemangioma. Many hemangiomata, in microscopic section, show areas of fatty and hyaline degeneration, which were markedly present in this instance. One small section of the specimen in this case was suggestive of the remains of a hemangioma. It is probable that the phlebolith in this instance cut off the blood supply with resultant degeneration of the tumor. Foreign-body irritation occurred some time later, as evidenced by the histological picture, and there was a recurrence of the tenderness to a blow. The obliteration of the tumor did not give permanent relief from the symptoms, and, in this instance at least, the phlebolith must have been a factor in the production of pain.

Excision is the treatment of choice and is eminently satisfactory. Some of the widely invasive angiomata present marked mechanical difficulties in their removal, and instances of severe hemorrhage have been reported. The injection of a variety of sclerosing solutions and radium and x-ray therapy have been utilized in the treatment, but these methods have not proved nearly as efficient as surgery. Some type of surgical removal was done in all of the 142 cases in this series where the type of treatment was stated. There were four amputations and one resection of the knee joint. There was recurrence of the tumor in seven instances, one as late as eight years following excision. It is suspected that recurrence is more prevalent than these statistics indicate, since many cases were followed for only a short period and a note on the result was frequently omitted. One death occurred, but this was due to "exhausting diarrhoea" and not to the hemangioma.

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POSTERIOR DISLOCATION OF THE ELBOW JOINT COMPLICATED BY FRACTURE OF THE MEDIAL EPICONDYLE AND ULNAR-NERVE INJURY

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Posterior dislocation of the elbow does not as a rule present many difficulties in the way of treatment. Occasionally, however, complications arise, which, if not recognized and properly treated, result in considerable loss of function in the affected joint. An important and not infrequent complication is fracture of the medial epicondyle. The displaced fragment may become incarcerated in the joint fissure at the time of reduction, with consequent limitation to full motion, and eventually a traumatic arthritis develops. At times the epicondylar fragment is accompanied by the ulnar nerve, and symptoms of a typical ulnar neuritis soon appear. The clinical and roentgenographic findings are quite characteristic,—namely, a block to motion, bony in character; ulnar neuritis occurring immediately or within a few days; an extra shadow in the joint space representing the detached fragment; and the absence of the medial epicondyle from its usual place in the roentgenogram. This is a syndrome which could not apparently be overlooked. Writers on the subject, however, agree that this condition is in fact frequently overlooked. In a large measure this is due to the paucity of literature on the subject. Standard textbooks, as a rule, make no mention of this

FIG. 1-A

FIG. 1-B

Case 1. Demonstrating the detached epicondyle displaced downward and lying in the joint.

condition. Only a few articles dealing with the subject have appeared in the medical periodicals during the past few years. These include papers by Speed and Macey, Cotton, and Stern.

Three cases with displacement of the detached medial epicondyle into the joint have been seen at The Guthrie Clinic. In two of these, symptoms of ulnar neuritis were present.

CASE REPORTS

CASE 1. H. G., a male, seventeen years old, came to the Hospital after direct injury to the elbow, complaining of marked tenderness on the inner side of the elbow and some deformity. A small area of anaesthesia over the dorsal surface of the ulnar side of the hand and the little finger was found clinically, with no apparent motor disturbance. There was no interference with the circulation. A diagnosis of dislocation of the elbow, chipped fracture of the medial epicondyle, and contusion to the ulnar nerve was made. After closed reduction of the dislocation and the fracture, a plaster splint was applied. Check-up roentgenograms, taken after reduction, still showed the presence of a fragment of bone within the joint and, accordingly, the patient was strongly urged to consent to surgical intervention. He refused and has since been lost sight of. When last seen, he had had no return of sensation in that area of the hand and the forearm supplied by the ulnar nerve and was unable to extend the elbow completely.

CASE 2. H. S., a male, thirteen years old, came to the Hospital complaining of pain in the right elbow, which had been present for three days following a fall. Examination on admission revealed marked swelling about the right elbow with discoloration most marked about the medial aspect of the arm. No areas of anaesthesia were found over the forearm or the hand, but there was a definite muscle

FIG. 2-A

FIG. 2-B

Case 2. The epicondyle is seen lying within the joint before operative removal.

FIG. 3-A

FIG. 3-B

Case 3. Before reduction. Showing the epicondyle displaced downward.

palsy in that portion of the hand supplied by the ulnar nerve. The patient was unable to extend the forearm completely, and, on any attempt to extend the part, he complained of a burning sensation shooting into the hand and the little finger.

FIG. 3-C

Case 3. Anteroposterior view after closed reduction. The epicondyle is shown near its epiphyseal bed. (The lateral view after reduction does not show the epicondyle.)

A roentgenogram showed separation of the epiphysis of the medial epicondyle of the right humerus. In view of the fact that the detached epicondyle had entered the joint, as evidenced by its position in the roentgenogram and by the presence of a "locked joint", the patient was urged to have surgical intervention, to which he consented. An incision was made along the medial aspect of the elbow, and the joint cavity was entered. At first, some difficulty was encountered in locating the detached epicondyle within the joint, but, after the ulnar nerve had been identified and isolated in the lower arm and followed downward, it was found to lead to the fragment of bone that had been displaced into the joint. The epicondyle was removed completely and the ulnar nerve was transplanted anteriorly. After an uneventful convalescence, the patient was discharged, employing active motion. At the time of his discharge he had had some return of the motor function along the ulnar side of the forearm and the hand. However, when seen eight weeks after operation, there was marked flaccidity of the pollicis adductor muscle with marked wasting in the inter-

osseous spaces. The patient was unable to adduct the little finger. Sensation was almost normal.

CASE 3. W. C., a young boy, was recently admitted to the Hospital with a dislocation of the elbow and with the medial epicondyle displaced downward and forward. Reduction of the elbow dislocation was easily accomplished with right-angle traction, and the epicondyle was manipulated upward and backward to resume its normal relationship with the lower inner aspect of the humerus. No ulnar symptoms could be demonstrated either before or after reduction. In this instance, closed reduction was successful in overcoming one of the complications associated with posterior dislocation of the elbow.

SUMMARY

1. Fracture of the medial epicondyle may be a complication of posterior dislocation of the elbow joint.

2. Occasionally, in reduction of the dislocation, the detached epicondyle may become incarcerated in the joint with consequent limitation to full motion and with the possibility of the development of a traumatic arthritis at a later period.

3. Operative removal is indicated if closed manipulation is unsuccessful in removing the detached epicondyle from the joint space.

4. Occasionally, the ulnar nerve is carried along with the epicondyle, and an immediate or delayed ulnar neuritis may develop.

5. Operative interference is indicated if an ulnar neuritis occurs.

6. If an open operation is required in the treatment of these complications of posterior dislocation of the elbow, removal of the epicondyle from the joint and transplantation of the ulnar nerve anteriorly are the objectives.

7. These particular complications should be kept in mind in cases of posterior dislocation of the elbow joint, especially in children.

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CURARE THERAPY FOR THE RELEASE OF MUSCLE SPASM AND RIGIDITY IN SPASTIC PARALYSIS AND DYSTONIA MUSCULORUM DEFORMANS

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The use of curare in spastic paralysis and in certain of the dystonic diseases such as dystonia musculorum deformans, spasmodic torticollis, and the dystonic syndromes is based upon the fact that curare has the specific effect of interrupting the transmission of the nerve impulse to muscle. This action, which takes place at the myoneural junction, is such that it strikes at hyperinnervated muscles before it affects normal musculature. This is true experimentally and clinically. The action of the drug is a peripheral one. No distinction in treatment need be made then between lesions of the pyramidal tract and those of the extrapyramidal tract. The response to curare, however, is better in lesions of the extrapyramidal tract.

The use of curare in experimental medicine is well known. The attempt to use curare clinically dates back to 1857 when its specific effect was discovered by Claude Bernard. Each clinical test repeatedly emphasized the fact that each sample of curare was variable in strength and each test indicated the necessity for standardization of the curare mixture.

The curare which the author used was made up by the Merck Institute of Therapeutic Research. Each sample of curare was accurately assayed so that four and four-tenths milligrams was a lethal dose for one-half of the white mice into which it was injected. The curare was put up as a light brown, sterile, aqueous solution in ampules containing ten cubic centimeters, each cubic centimeter of curare being the equivalent of five milligrams. This solution was not self-sterilizing.

This curare was so accurately assayed that one sample acted as another and in quantitative exactness.

Curare is given either intramuscularly or intravenously. It was given intravenously when the quantity of fluid to be administered was too great for intramuscular injection. Dosage is estimated by weight of the patient and by extent of muscle spasm and muscle rigidity. It varies, then, for each patient. It is most in the dystonic patient, whose average dose has been twenty-five milligrams, given intravenously. The average spastic patient, intelligent enough to cooperate, needs about fifteen to forty milligrams given intramuscularly, or ten to fifteen milligrams if given intravenously. Each patient's dose must be estimated separately. It is best to begin with an ineffective dose and work up to the effective or

* Service of Leo Mayer, M.D.

stabilizing dose. A dose beyond twenty-five milligrams given intravenously must be exceeded cautiously.

An increasing dose usually gives increasing effect up to that point where the central symptomatology becomes too unpleasant. An overlap effect is present if the drug is given frequently enough.

The excretion of the drug is rapid and limits the duration of effect which is usually one to two days, but the duration may vary from four hours to several days.

The drug is injected every day or three times weekly, as a rule. The repetition of the curare is not harmful.

The central symptomatology is manifest about fifteen to twenty minutes after intramuscular injection, or during or immediately after intravenous injection. This symptomatology is not constant in the smaller doses but increases with clinically effective dosage.

The patient becomes a little dizzy and sometimes sleepy. The eyes feel fluttery, and there seems to be a mist before them. The upper lids are heavy and sometimes partly dropped, and it becomes difficult to open the eyes. Diplopia is sometimes present. With larger doses, there is facial masking so that the face seems to bear an expression of amazement, stupefaction, or blankness.

These symptoms are not unwelcome to the patient who may accept them as a sign of activity of the drug. They last for ten to thirty minutes.

Toxic symptoms were observed in two cases in whom doses of more than thirty milligrams were given intravenously. The mouth was open and saliva drooled from it. The color of the face was ashen gray. The eyes were held half closed and the facial expression was fixed. The head hung heavy as if its weight were too great for the neck. The patient was unable to walk because of dizziness and ataxia. There was no disturbance in breathing.

These alarming symptoms pass quickly. They will only be noted after the injudicious use of too great a dose of curare.

The *muscle effect* depends on a theoretical muscle-relaxing component in curare, as opposed to the paralyzing component. It is not possible to render a limb completely flaccid within the range of therapeutic dosage. But there is an elective release of muscle spasm and rigidity which leaves normal musculature unchanged. Certain muscle groups are more sensitive to curare and it is usually difficult to overcome thenar spasm and palmar flexion of the wrist. Soft-muscle rigidities respond better than those of hard ones. The estimate of rigidity is tested empirically by palpation of the muscle. Plastic suspension of a limb is often overcome. Abnormal movements diminish. Clonic or hyperactive reflexes are lessened or the reflex is brought out when extreme muscle rigidity originally prevented its appearance. The extent of actual paralysis or paresis of muscles can be estimated after curare. By release of spasm and rigidity, a limb may show active power where none seemed

to exist before. The author has been particularly interested in the hand and has taken the movement of picking up a glass of water and drinking from it as a large gross movement in testing for useful muscle power after curare.

Curare can not alter fixed contracture or deformity.

Pulse and blood pressure are not affected with the usual therapeutic dose. No constant pupillary change or nystagmus has been noted. No curare glycosuria was noted when test was made for urinary sugar.

The effect of curare is most striking in dystonia musculorum deformans. The effect may be dramatic. A bedridden patient becomes able to stand and even to walk, as in a walker. Dystonics with extreme rigidity may be benefited only a little, but it is worth while to try the drug in each case. The drug is useful, too, in fractional dystonic syndromes, as spasmodic torticollis.

SUMMARY

Properly assayed curare is safe in therapeutic dosage. This drug has a definite place in the release of muscle spasm and rigidity in spastic paralysis and dystonia musculorum deformans.

ARACHNODACTYLIA

A Report of Eight Cases

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Arachnodactylia, an entity considered to be comparatively rare, occurs more frequently than is generally believed. Most of the cases that have been described appear in the literature on ophthalmology. Yet the patient with arachnodactylia should certainly be of as much interest to the orthopaedic surgeon as to the ophthalmologist. However, the orthopaedic literature contains very little information on this condition. In fact, most of the leading orthopaedic textbooks give but a few lines on the subject, and leave the reader with the impression that the syndrome is very unusual. Marfan first described the condition in 1896. The foreign literature contains about ninety reported cases of arachnodactylia, while the English literature contains less than twenty-five cases, very few of which have been reported from the United States. Because so few have been mentioned in the literature of this country in proportion to the ones in foreign countries, and because, in the last seven years, eight cases of arachnodactylia have been observed in this Clinic, one is led to believe that the condition is much more common than is generally recognized.

The most important characteristics of arachnodactylia are the long, slender extremities which are most noticeable in the more distal portions of the limbs, the marked relaxation of nearly all of the joints, a general lack of normal muscle tone, and the presence of very little subcutaneous fat. The hands and feet are especially long and narrow. The phalanges are of abnormal length; hence the name "spider digits". Almost invariably, besides these symptoms, there are other congenital deformities. These abnormalities vary in number and in degree of severity. Certain defects are found in a high percentage of the cases. The head is usually of the dolichocephalic type. Eye complications—the most common of which are ectopia lentis and iridodonesis—are present in about 40 to 50 per cent. of the cases. If the lens is not dislocated, lenticular myopia is frequently present. Other eye complications, such as chorioretinitis, have been observed. The ears are usually large. The upper half of the auricle protrudes, but the lower half is in close apposition. The auricular cartilage is usually underdeveloped. In most cases, the mouth shows a characteristically high palate. Abnormalities often occur in the teeth, one of the more common of which is a marked "overbite". The teeth may be long and narrow, and double rows of teeth have been reported. The chest frequently shows deformity, such as pigeon breast. Winged scapulae are very often noted. The spine, in many of the cases, shows

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marked deformity of various types, such as extreme kyphosis and lordosis, and, most commonly, kyphoscoliosis. Spina bifida is not an uncommon finding. The heart is affected in about 45 per cent. of the patients, various congenital defects such as patent foramen ovale and incompetent valves being the most common forms of disorder. Various abnormalities of the blood vessels have been observed. Abnormal division of the lobes of the lungs has been seen at autopsy. In addition to the abnormal length of the extremities, webbing of the fingers and toes and various forms of contractures have been described. However, it is more common to see disturbances due to marked relaxation of the joints, such as extremely relaxed flat feet. Acrocyanosis is frequently present. Roentgenographic examination shows rarefaction of the bones and advancement of ossification. Mentality is usually normal.

Arachnodactylia occurs about equally in the two sexes. Weve, in tabulating eighty-two reported cases, found it in forty females and in

FIG. 1-A

Case 1. F. S. Pigeon breast, long slender extremities.

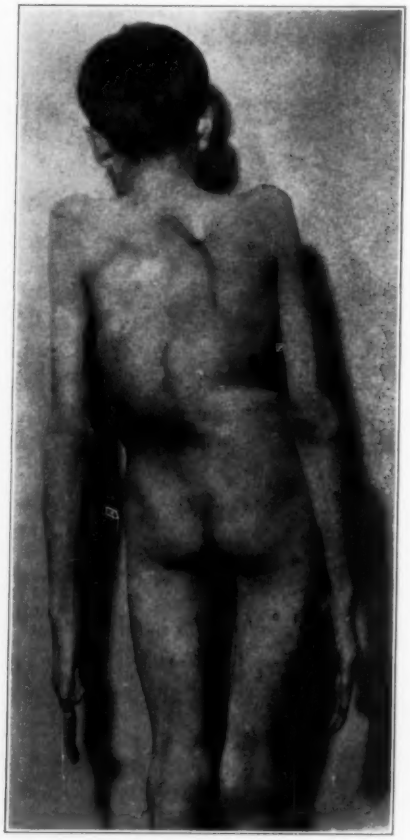

FIG. 1-B

Severe kyphoscoliosis.

forty-two males. Race apparently is of little significance. The disease is definitely familial. There has been considerable controversy concerning the exact etiology of arachnodactylia. The most widely accepted theory today is that it is due to a disturbance of mesoblastic growth. With the exception of the eyes, only mesoblastic tissues are involved. Most probably, the lens, which is of ectodermal origin, is secondarily affected by the weakening of the supporting tissues which most authors believe to be of mesodermal origin. The diagnosis is made on the finding of extremely long, slender, relaxed extremities accompanied by other congenital deformities, particularly those involving the eyes. There are certain other diseases that must be considered before arriving at the final diagnosis. The Charcot-Marie-Tooth type of atrophy is a progressive disease and should not offer any great difficulty in the differential diagnosis. Status dysgraphicus or microform syringomyelia presents a picture similar to arachnodactylia, with the exception of the eye findings. In the former there are usually present heterochromia of the iris, Horner's syndrome, and occasionally cataract; in contrast to the dislocation of the lens and the poor reaction of the iris to mydriatics in the latter.

From the orthopaedic surgeon's standpoint, the treatment of arachnodactylia is concerned with the correction of the existing deformities. Of the eight patients whose cases are presented in this paper, the first two are a brother and sister. The next four patients are from one family, while the last two are not related.

CASE REPORTS

CASE 1. F. S. (No. 47637), a poorly nourished white boy, thirteen years of age, entered the Hospital because of curvature of the spine. His past history and family history were negative, except for the usual childhood diseases.

The patient was a thin, poorly nourished individual. His head was dolichocephalic in type. Examination of the eyes revealed blue sclera and anomalous discs with deep cups. There was an incomplete central scotoma for colors in both eyes. The ears were large with a decreased amount of auricular cartilage. Examination of the mouth showed a highly arched palate and very irregular and carious teeth. The chest was of the pigeon-breast type. The heart was enlarged to the left with a thrill at the apex. A diastolic murmur was present just inside the nipple line. Examination of the back revealed scaphoid scapulae, and a marked right high dorsal, left thoracolumbar kyphoscoliosis. The fingers were very long and tapering, and there was considerable wasting of the palmar muscles. The feet were long and narrow. Marked generalized muscle atrophy and definite acrocyanosis were noted. Laboratory findings were negative. The patient died of heart disease at the age of twenty.

FIG. 2

Case 2. L. S. Narrow hands with tapering fingers.

CASE 2. L. S. (No. 47638), an undernourished girl of nine years, a sister of the patient in the preceding case, entered the Hospital on December 30, 1930, for observation. Her chief complaint was curvature of the spine, which had existed since birth. The birth history was normal. Long fingers had been noted at birth. The patient had never been ill.

The head was of the dolichocephalic type with a prominent forehead. There was slight bilateral ptosis of the eyes. The eyeballs were rather prominent. Blue sclera and anomalous discs with deep physiological cups were noted. The visual fields were normal. The ears were large and flabby. Examination of the mouth revealed a highly arched palate and irregular teeth. The chest was of the pigeon-breast type. The heart showed normal limits, and a loud systolic murmur was heard at the apex. Examination of the back revealed scaphoid scapulae and right thoracic, left thoracolumbar kyphoscoliosis. The extremities showed marked relaxation of all joints. The hands and feet were long and narrow. The feet were markedly pronated, and the longitudinal arches were low. There was marked atrophy of the palmar and plantar musculature, with a peculiar reddish color of the palms. Roentgenographic examination showed elongation of the long bones of the hands and feet, particularly of the phalanges.

This patient is still alive and is in fairly good general health.

FIG. 3-A

Case 3. J. D. Pigeon breast, long slender extremities, tapering fingers.

CASE 3. J. D. (No. 57775), a tall, undernourished, twelve-year-old white girl, was first seen at the Orthopaedic Clinic on September 12, 1935. Her chief complaint was flat feet; her past history was negative.

Examination of the mouth disclosed a highly arched palate. The teeth showed a marked overbite. The chest was of the pigeon-breast type. The left border of the heart was one-half an inch to the left of the nipple. A systolic murmur was heard from the second interspace to the fifth interspace. Examination of the back showed a moderate right thoracic, left lumbar scoliosis. Both the upper and the lower extremities were long and narrow. The elbows and knees could be readily hyperextended. All the joints showed definite relaxation. The fingers and toes were longer than in normal individuals. There was a mild degree of genu valgum. The feet were markedly pronated, and the longitudinal arches were low. Roentgenographic examina-

FIG. 3-B

Irregularity of teeth with malocclusion.

tion of the head revealed a long skull with normal tables, sella turcica, and sutures. The spine showed right thoracic, left lumbar scoliosis. Roentgenographic examination of the hands showed unusually long metacarpals and phalanges. There was a mild degree of decalcification of the bones in general.

On November 5, 1935, bilateral navicular-cuneiform arthrodeses were performed to correct the flat feet. The result was very satisfactory.

CASE 4. K. D. (No. 40695), a fairly well-nourished white boy, four years of age, a brother of the patient in Case 3, was first seen in the Orthopaedic Clinic on December 7, 1933, because of knock-knee deformity and pronated feet.

The head was of the mild dolichocephalic type. There was bilateral iridodonesis of the eyes with subluxation of the lens. The palate was found to be highly arched. The teeth were normal except for several which were carious. The chest was of the pigeon-breast type. Examination of the heart revealed a systolic murmur over the second interspace on the right when the patient was standing and on the left when he was recumbent. There was a right thoracic, left lumbar curvature with an increase in the thoracic rounding and lumbar lordosis. The hands and feet were long and slender. Moderate genu valgum and marked pronation of both feet were noted. Roentgenographic examination showed that the skull was long, but otherwise normal. The sella turcica was normal. The spine had a right thoracic and left lumbar curvature.

FIG. 4

Case 4. K. D. Pigeon breast, abnormally long extremities, genu valgum, and pronated feet.

CASE 5. G. D. (No. 42978), a tall, poorly nourished, white male, eight years of age, a brother of the patients in Cases 3 and 4, was first seen in the Orthopaedic Clinic on October 28, 1935, because of kyphoscoliosis and flat feet.

The head was of the square type with prominent parietal bosses. There was bilateral subluxation of the lens of the eyes. The palate was normal. The teeth were irregular in shape and size, and there was marked overbite. The chest was of the pigeon-breast type with a definite Harrison's groove. Examination of the back showed marked thoracic rounding with a moderate right thoracic, left lumbar scoliosis. The fingers were moderately long. The feet were long and narrow and markedly pronated. The muscles were flabby. The skin was cold and clammy. Roentgenographic examination of the gastro-intestinal tract revealed an incomplete rotation of the colon, the sigmoid and descending colon being on the right side. The skull was long, and the sella turcica was normal. The spine had a moderate right thoracic, left lumbar curvature.

CASE 6. H. D., father of the patients in Cases 3, 4, and 5, showed the main characteristics of arachnodactylia, although a complete study of his case was not made. He died of heart disease in April 1937. He was a tall, poorly nourished individual, measuring six feet six inches in height. The head was of the dolichocephalic type. The chest showed a marked deformity in the protrusion of the lower end of the sternum. A loud diastolic murmur was heard over the entire precordia. The blood pressure was 130/55. The extremities, particularly the hands and the feet, were abnormally long and thin.

This man's wife was apparently normal in every respect. They had four children,—three of them are here reported and the fourth was normal.

FIG. 5-A

Case 6. H. D. Protrusion of lower end of sternum.

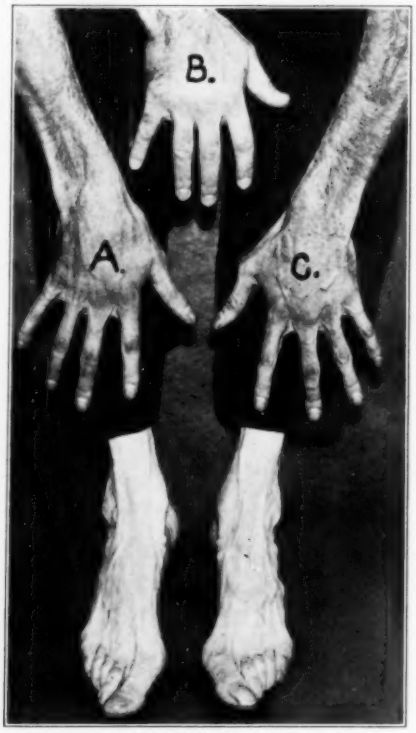

FIG. 5-B

A and *C:* Patient's hands. *B:* Normal hand for comparison. Unusually long and narrow feet.

CASE 7. D. W. (No. 38022), an underdeveloped white girl, was first seen at the Clinic on July 1, 1929, at the age of two and one-half years, because of a limp on the left side. The limp had been noticed when she first began to walk at eighteen months. The birth history was normal, and she had had no sickness.

Examination showed a fairly well-nourished white girl with a gait typical of congenital dislocation of the left hip. The head was irregular in shape with large parietal bosses. Examination of the eyes showed congenital dislocation of each lens. The palate was highly arched, and the teeth were irregular. Examination of the chest showed

FIG. 6-A

Case 7. D. W. Characteristic hands, showing tapering fingers.

FIG. 6-B

Extremely pronated flat feet.

flaring of the lower ribs. The border of the heart was enlarged to the left. There was a systolic murmur over the pulmonic area. The spine was straight at the first admission. Examination of the extremities revealed congenital dislocation of the left hip. The hands and feet were long and slender. The arches were low, and there was generalized relaxation at all joints.

The dislocation of the left hip was reduced by closed manipulation on July 3, 1929. A good result was obtained. In 1934, a right thoracic, left lumbar scoliosis developed. On May 11, 1937, bilateral navicular-cuneiform arthrodeses were performed in an effort to correct the flat feet. A very satisfactory result was obtained.

FIG. 6-C

Abnormally long extremities, pronated feet, congenital dislocation of left hip.

CASE 8. F. K. (No. 15583), a white girl, ten years of age, was seen for the first time in the Clinic in October 1934, because of a deformity of the cervical spine which had existed since birth. This patient was a twin; her brother was living and well. The father and mother were also living and well. The patient had had an appendectomy in July 1934.

The head was of the dolichocephalic type. Examination of the eyes showed a left convergent strabismus and left corneal leukoma. The head was held deviated to the right. The chest was of the pigeon-breast type. There was a systolic murmur at the apex of the heart. The back exhibited moderate thoracic rounding with deviation of the upper thoracic spine to the right. The extremities showed an increase in length of the hands and the feet and general muscle relaxation. Roentgenographic examination revealed a definite hemivertebra on the left side at the cervicothoracic area, with congenital fusion of the upper cervical vertebrae. Also, there was a synostosis between the first and second ribs on the left.

From a review of the literature and from a study of these eight cases, we feel that arachnodactylia is a much more common entity than it has generally been considered in the past. As may be seen in these cases, the number and severity of the accompanying deformities are variable. There may be gradations anywhere from the very mild to the very severe forms of arachnodactylia. The recognition of the multiple congenital deformities should be of particular interest to the orthopaedic surgeon.

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CHANGES SIMULATING LEGG-PERTHES DISEASE (OSTEOCHONDRITIS DEFORMANS JUVENILIS) DUE TO JUVENILE MYXOEDEMA

Report of a Case

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It seems worth while to report the following case history, because the facts which it brings out have been largely overlooked.

CASE REPORT

The patient, male, aged thirteen, was first seen on October 10, 1935, because of retarded growth and a limp. He had been well and large for his age until he had had an attack of pneumonia at the age of three. Since that time he had seemed less well. Growth had been retarded, and he had done poorly at school; more recently a limp had been noted. From the age of six he had been taking very small doses of thyroid (one-tenth of a grain, Burroughs Wellcome, six times daily).

On physical examination he had the outward appearance of hypothyroidism (Fig. 2,*A*), but was mentally alert. His skin was dry and his hair was coarse and dry. There was a very slight limp. His height was 129.2 centimeters. These findings suggested juvenile myxoedema as a cause of his failure to grow. Cretinism could be ruled out by his good mentality and by the fact that he had been normal until the age of three.

A roentgenogram of the hands (Fig. 1,*A*) showed marked retardation of bone age, which strongly supported the diagnosis. Roentgenographic examination of his hips (Fig. 3,*A*) showed what was interpreted as bilateral Legg-Perthes disease.

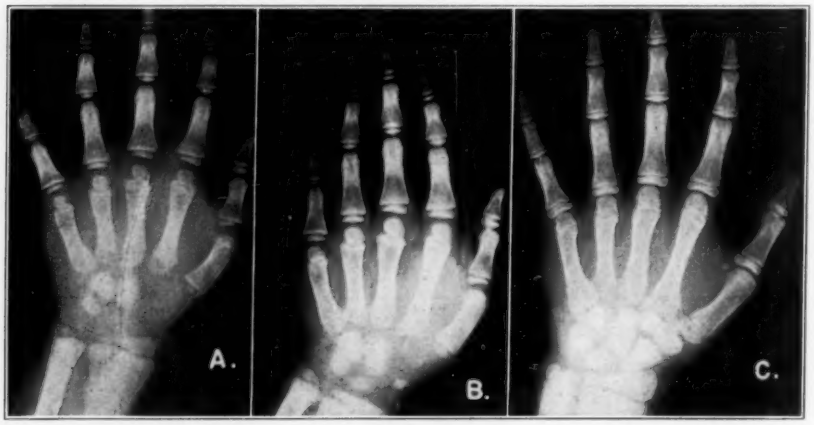

Fig. 1

A: Left hand on January 13, 1936, at the age of thirteen. Note marked retardation of bone age.
B: Left hand on June 25, 1936. Note the effect of thyroid treatment on bone age.
C: Left hand on December 4, 1937.

FIG. 2

A: Patient on October 10, 1935, at the age of thirteen, before adequate thyroid treatment.
B: Patient on June 25, 1936, seven months after the institution of thyroid treatment.
C: Patient on November 13, 1937, two years after thyroid treatment was begun.

A basal metabolic-rate determination was minus 16 (weight standard).

Although the accepted orthopaedic treatment for the hip condition is to stop all weight-bearing, this seemed rather drastic and, in view of the fact that the patient had one disease which could be treated, it seemed justifiable to see whether the hip condition (the connection between this and the hypothyroidism was not then appreciated) might not likewise respond to thyroid medication. Accordingly, he was given one grain of

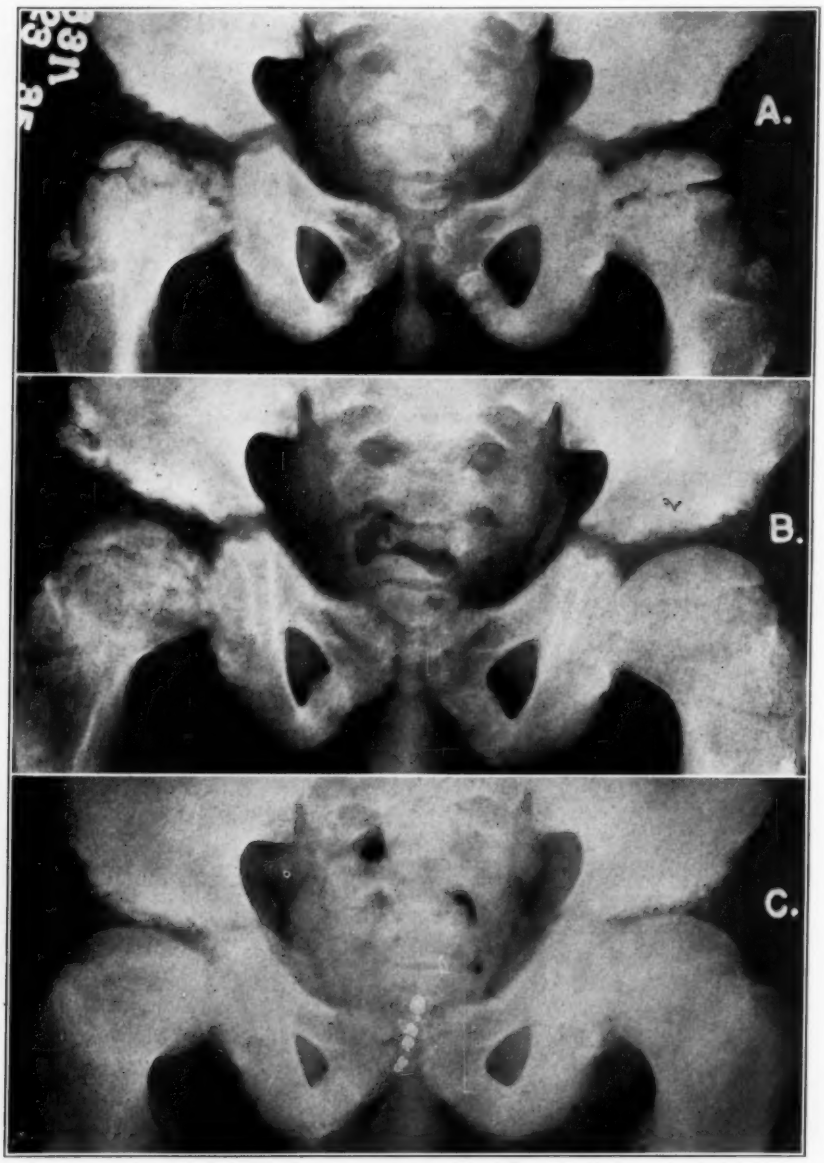

FIG. 3

A: November 23, 1935, at the age of thirteen.
B: June 25, 1936.
C: November 13, 1937.

Armour's thyroid daily; in a few weeks the dosage was increased to one and one-half grains daily. Since one grain of Armour's thyroid is equivalent to one grain of U.S.P. thyroid, whereas one grain of Burroughs Wellcome thyroid equals only two-fifths of a grain of U.S.P. thyroid, it will be seen that the dosage was much increased.

The patient immediately improved in all respects. The limp disappeared, and he gained eight centimeters in height in the next seven months. (See Figure 2,*B*.) The bone age increased in a most astonishing manner (Fig. 1,*B*). The femoral epiphyses showed marked improvement (Fig. 3,*B*).

When last seen, at the end of two years of treatment (Fig. 2,*C*), the bone age was no longer retarded (Fig. 1,*C*), the heads of the femora had entirely filled in (Fig. 3,*C*), and the patient had gained twenty-five centimeters in height during the two-year period.

DISCUSSION

This case shows that a condition which has the roentgenographic appearance of Legg-Perthes disease may occur in hypothyroidism and can be cured by thyroid medication. Similar observations to the ones here reported were made by Cavanaugh and Shelton, who found in five cases of what they considered Legg-Perthes disease a family history of colloid goiter, retardation of bone age, and striking improvement following thyroid medication. The questions of course arise as to how constant such epiphyseal changes are in hypothyroidism and whether all cases of Legg-Perthes disease are on a hypothyroid basis.

That epiphyseal changes occur in cretinism has been well recognized in the German literature since the monograph by Bircher in 1909 on the

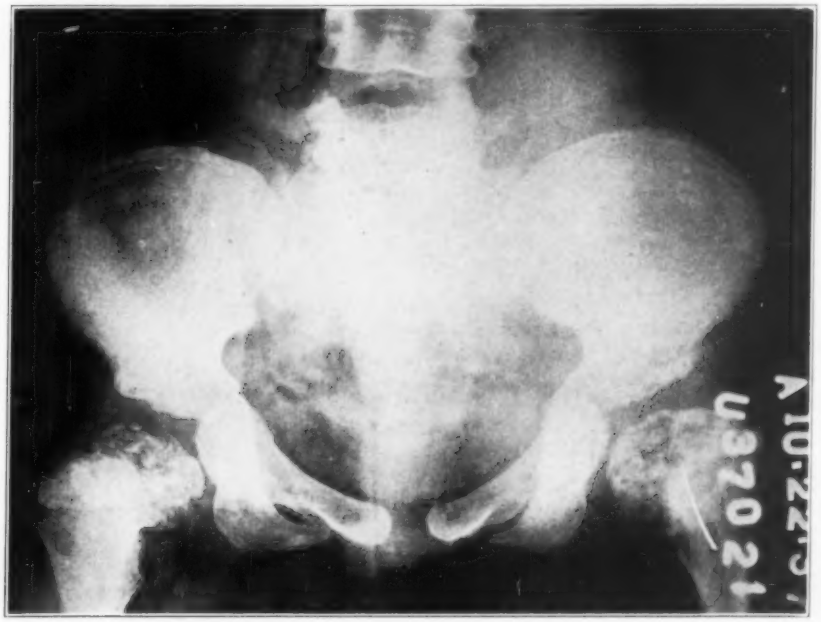

FIG. 4

Roentgenogram of the hips of an untreated case of cretinism (patient aged twenty-four).

FIG. 5

Section through the head of the femur of a cretin, showing bone pathology to be a delay in transformation of cartilage into bone. Reproduced from Looser, p. 355. (*Courtesy of Gustav Fischer.*)

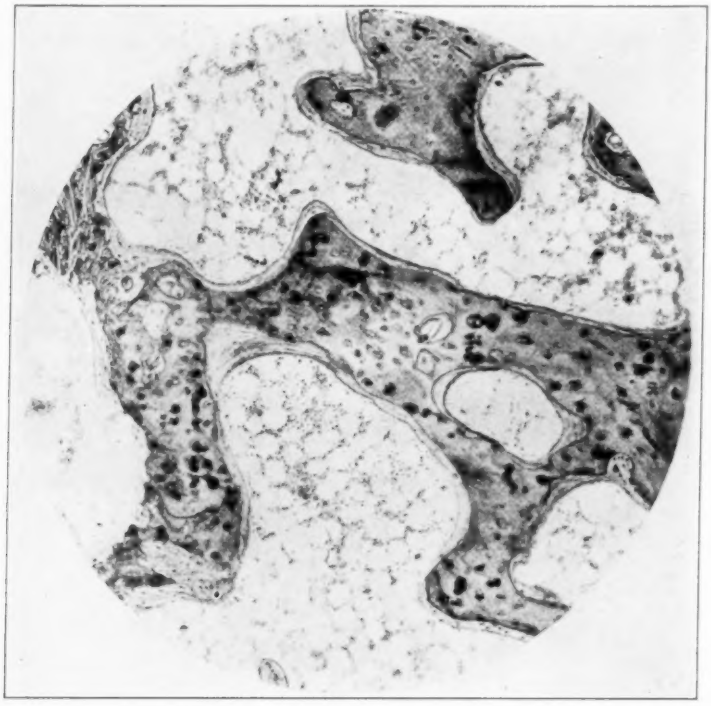

FIG. 6

Drawing of trabeculae composed almost entirely of cartilage with only a surface covering of bone. Reproduced from Looser, p. 353. (*Courtesy of Gustav Fischer.*)

skeletal changes in cretins. In fifteen of twenty-six cases of cretinism, Looser found changes in the femoral epiphyses similar in regard to their

roentgenographic appearance to those seen in Legg-Perthes disease. Wilkins, at the Johns Hopkins Hospital, who has made a study of cretinism, has seen multiple instances of the condition. The author has seen recently at the Massachusetts General Hospital on the Service of Dr. Harold L. Higgins, a cretin (L. B., M. G. H. No. 87021), aged twenty-four, who has received almost no thyroid medication during her life, and in whom epiphyseal changes are present. (See Figure 4.)

The pathology of the epiphyseal changes in hypothyroidism was beautifully demonstrated by Looser, who found it to be a retardation in the transformation of cartilage into bone in the epiphyses. (See Figures 5 and 6.) Since the pathology in Legg-Perthes disease is aseptic subchondral necrosis of the epiphysis (Zemansky), Looser was probably right in emphasizing that the epiphyseal lesion in hypothyroidism is not Legg-Perthes disease, although often mistaken for it clinically. This explanation of the pathology is most logical in view of the accompanying retardation of bone age seen in cretinism and in juvenile myxoedema.

SUMMARY

1. In the case of juvenile myxoedema reported, roentgenographic examination showed changes indistinguishable from Legg-Perthes disease. These changes promptly cleared up on thyroid medication.

2. From the literature, it is clear that lesions occur in the epiphyses of cretins, which are similar roentgenographically to those seen in Legg-Perthes disease. From the work of Looser, however, it appears that the pathology in the epiphyses in the two conditions is entirely different.

3. Hypothyroidism and, as suggested by Shelton and Cavanaugh, retarded bone age should be looked for in all cases of apparent Legg-Perthes disease.

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TRAUMATIC DISLOCATION OF THE HIP FOLLOWED BY PERTHES' DISEASE

BY RAPHAEL R. GOLDENBERG, M.D., PATERSON, NEW JERSEY

From the Hospital for Joint Diseases, New York City, and Barnert Memorial Hospital,† Paterson*

The association of traumatic dislocation of the hip with Perthes' disease was first drawn to the author's attention by the case to be reported. The recognition of this association is of value because of the light which it may throw upon the etiology of Perthes' disease. The factor of trauma in the etiology of this lesion is still a moot question. The case to be described is presented as an additional observation, which tends to confirm a traumatic etiology of Perthes' disease. Cases in which Perthes' disease has supervened upon traumatic dislocation of the hip have been published previously. A review of the literature discloses the following case reports.

Sundt, in 1920, reported two such cases of traumatic luxation in two boys, nine years of age, occurring nine months and three years, respectively, before the appearance of Perthes' disease. In 1919, Elmslie described a typical case of Perthes' disease which developed in the hip of a boy, four years of age, one year after he had had a traumatic dislocation. Rehbein, in 1922, reported a case of an eight-year-old boy, in whom a traumatic dislocation of the hip was followed one year later by Perthes' disease. Nicolaysen, in 1931, described a case of a boy, ten years of age, who had a traumatic dislocation of the hip, followed in one year by Perthes' disease.

To this group of five cases the author wishes to add the following case.

CASE REPORT

M. B., male, aged ten and one-half years, was admitted to the Barnert Memorial Hospital on November 1, 1934, immediately after an automobile accident. Roentgenographic examination (Fig. 1) on admission showed a subluxation of the right hip. There was no evidence of Perthes' disease, even when the roentgenograms were studied in retrospect. Under general anaesthesia, reduction was attempted and a plaster-of-Paris spica was applied. Postoperative roentgenograms (Fig. 2), taken on November 8, 1934, showed a complete dislocation of the right hip. On the same day the dislocation was reduced, and the right hip was immobilized in a plaster-of-Paris spica. Roentgenographic examination (Fig. 3) confirmed the reduction. The patient was discharged from the hospital on November 13, 1934. Three weeks later, the spica was removed and physiotherapy was instituted. Two and one-half months later, the patient walked without a limp and without pain.

The patient was perfectly well until December 1935 (thirteen months after the time of the accident), when he began to limp and to complain of slight discomfort in the region of the right hip and thigh with radiation of pain to the right knee. He was treated by means of salicylates, physiotherapy, and occasional rest in bed. In spite of all treatment, the pain and limp continued and gradually increased in severity.

* Service of Samuel Kleinberg, M.D. † Service of William Spickers, M.D.

The author was first consulted on February 22, 1937, and examination revealed a flexion-adduction deformity of the right hip, together with limited abduction and internal rotation. In addition, there was atrophy of the right thigh and calf, prominence of the right greater trochanter, and one-quarter of an inch of shortening of the right lower extremity. Roentgenographic examination (Fig. 4), on February 22, 1937, showed typical flattening of the right femoral head with irregular areas of condensation and rarefaction. The adjacent part of the neck was broadened and was irregular in density. The patient was fitted with a Thomas traction caliper brace and remained ambulatory.

Roentgenographic examination (Fig. 5), on August 23, 1937, showed the surface of the epiphysis approaching a more normal curve and its density returning to normal. Clinically, the patient had a complete range of painless motion and was otherwise symptom-free.

DISCUSSION

The assumption that there might have been a previous incipient Perthes' disease, the development of which was hastened by trauma, has little in its favor. A careful study of the early roentgenograms fails to disclose any evidence of epiphyseal disturbance or separation.

In a series of ninety-eight cases of Perthes' disease, forty-one of which were reported by Eyre-Brook and the remaining fifty-seven by Sutro and Pomeranz, 75 per cent. occurred between the ages of four and

FIG. 1

Roentgenogram, taken on admission on November 1, 1934, showing subluxation of the right hip.

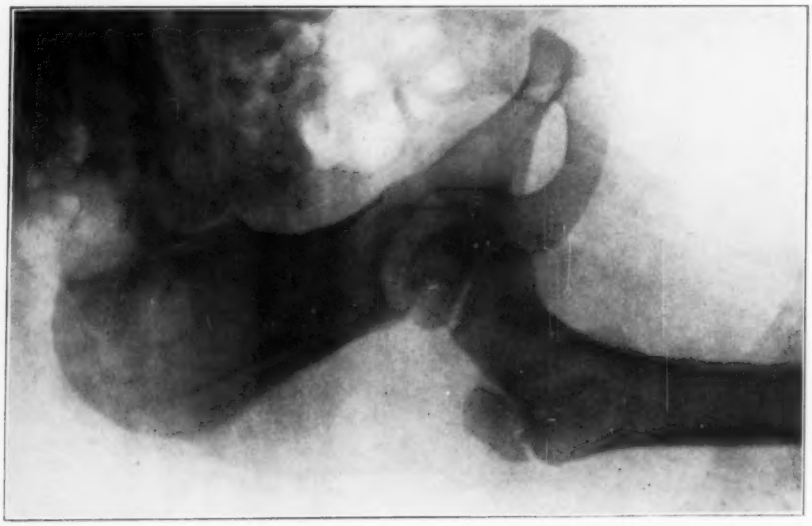

FIG. 3

Roentgenogram after reduction and immobilization of the right hip in a plaster-of-Paris spica.

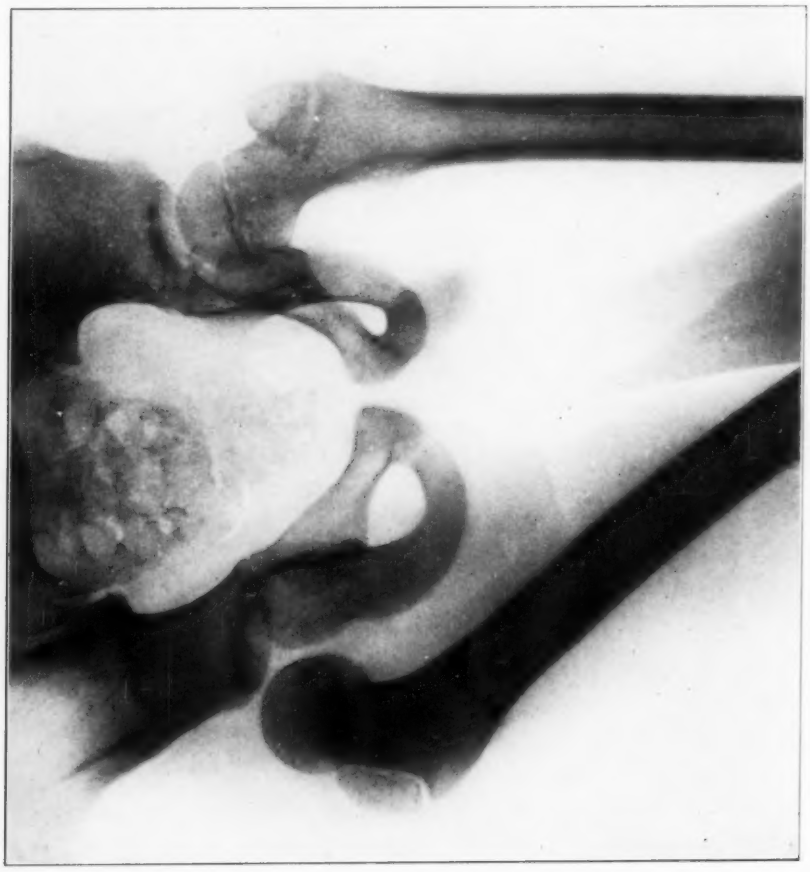

FIG. 2

Postoperative roentgenogram, November 8, 1934, showing a complete dislocation of the right hip.

FIG. 4

Roentgenogram, February 22, 1937, showing typical flattening of the right femoral head with irregular areas of condensation and rarefaction.

FIG. 5

Roentgenogram, August 23, 1937, showing the surface of the epiphysis approaching a more normal curve and the density returning to normal.

nine years. In the cases reported by Nicolaysen and the author, the patients were ten and ten and one-half years of age, respectively, when the dislocation occurred; this is somewhat later than Perthes' disease ordinarily occurs. The number of instances in which clinical and roent-

genographic evidence of Perthes' disease becomes manifest in hips following severe trauma indicates a more than casual relationship between the trauma and the subsequent development of Perthes' disease.

In treating cases of traumatic dislocation of the hip joint, the possibility of the development of an osteochondritis of the femoral epiphysis should be borne in mind.

While traumatic dislocation of a hip joint is rare, these six cases are additional evidence for the hypothesis of a traumatic etiology for Perthes' disease.

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BILATERAL CONGENITAL TALONAVICULAR FUSION

Report of a Case

BY PAUL W. LAPIDUS, M.D., F.A.C.S., NEW YORK, N. Y.

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Associate Orthopaedic Surgeon, Trinity Hospital,† Brooklyn

Congenital fusion of the tarsal bones was discussed by the author in the October 1932 issue of *The Journal of Bone and Joint Surgery*. A case of congenital talonavicular fusion was likewise reported. This case was considered the third on record in which only bilateral congenital fusion of the talonavicular joint was present, the other tarsal joints being normal. Review of the subsequent literature from 1932 to 1937 revealed only one more case of this apparently very rare malformation of the foot skeleton, that reported by Rothberg, Feldman, and Schuster.

In their patient, a girl, eight years old, bilateral talonavicular fusion was demonstrated in routine roentgenograms. Similar changes were discovered in the feet of the girl's brother, eleven years old, and also in those of her mother, thirty-one years of age. The boy had never had any foot trouble, but he likewise presented medial projection over the talonavicular region. The mother's feet appeared normal. This

FIG. 1-A

FIG. 1-B

Photographs of feet, showing the bilateral large projection over the medial aspect of the talonavicular region.

* Service of Leo Mayer, M.D. † Service of Harry Finkelstein, M.D.

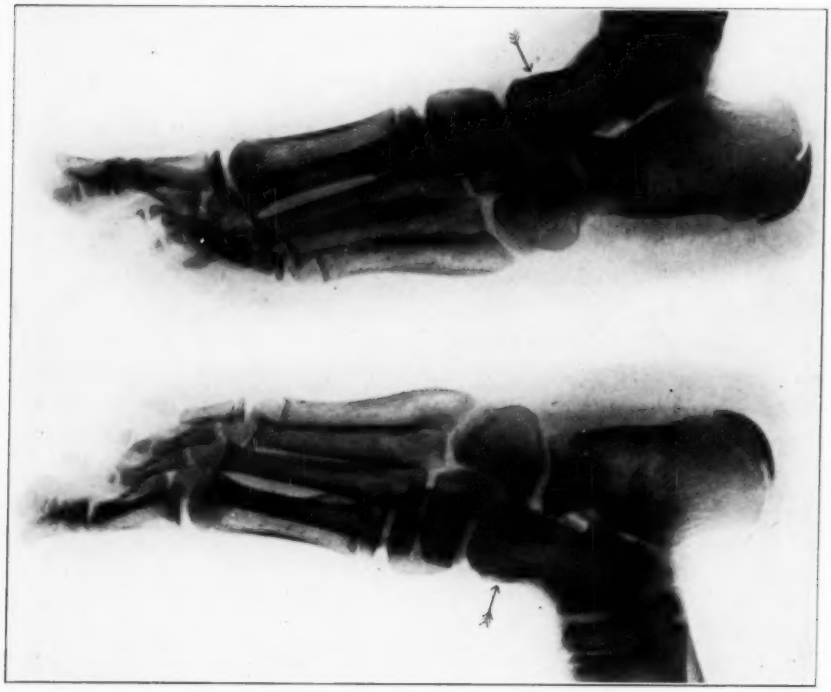

FIG. 2-B

Lateral view. The arrow points toward a linear density on the site of the talonavicular joint which failed to develop.

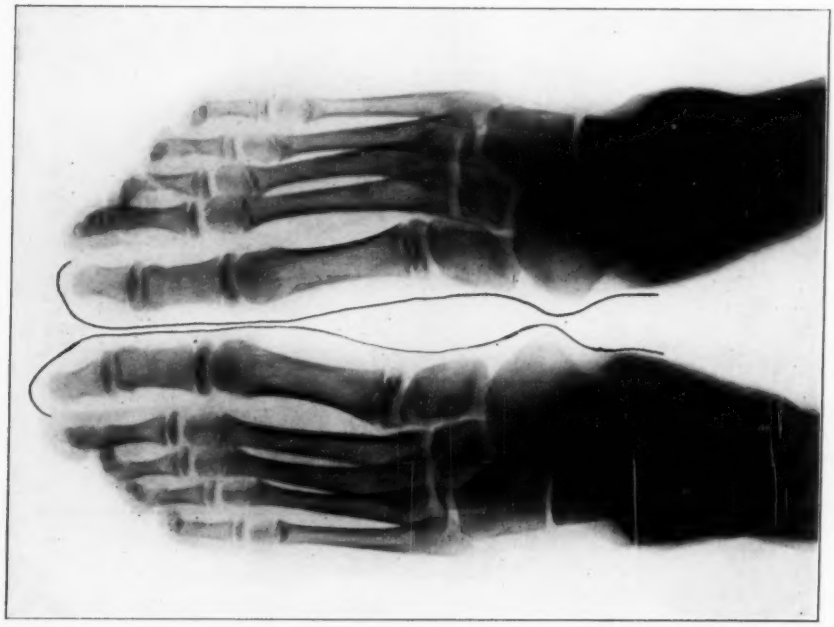

FIG. 2-A

Dorsiplantar roentgenogram of both feet. The outline of the soft-tissue shadow is retouched.

case is most interesting, as it is the only one on record which definitely proves the condition to be congenital and also hereditary.

Recently another case has come under the author's observation, a report of which follows.

CASE REPORT

E. C. (No. 63703), a colored girl, eleven years old, was brought to the Clinic of the Hospital for Joint Diseases on February 13, 1937, because of projections over the medial aspects of both feet. The condition had been present since infancy and, outside of occasional pressure symptoms from the shoes, had given her practically no discomfort.

None of the members of her family were known to have any foot deformity. Her past history was irrelevant, except for recurrent enlargement of lymph nodes on the left side of the neck. She was operated upon for this condition in July 1937, and a diagnosis of tuberculous lymphadenitis of the left cervical superficial nodes, with cold abscess formation, was made.

The patient was a tall, undernourished, colored girl with long, thin limbs. Upon examination, the general physical findings were essentially negative except for the tuberculosis of the left cervical lymph nodes. The blood Wassermann test was negative. Her feet were of the long, narrow type with very marked pronation and complete obliteration of the longitudinal arches. There was a bilateral projection about the size of a cherry on the medial aspect of the talonavicular region. (See Figures 1-A and 1-B.) This consisted of a bony prominence with fibrous subcutaneous enlargement appearing as a bursa. The skin over it was covered with a callosity, but there was no tenderness present. The posterior part of each heel did not come in contact with the ground, the sole giving the impression of a rocker bottom.

Dorsiflexion of the feet was possible to about 25 degrees. Hypermobility was also noted in all of the other joints of the foot except for marked restriction of lateral motion of the forefoot over the back foot. All motions were completely painless. There was good pulsation of the arteries of both feet. Motion of the toes was normal. The roentgenograms of the feet, in the dorsiplantar view, showed complete absence of joint space between the talus and the navicular. The medial part of the talonavicular bone was markedly prominent, and there was considerable soft-tissue enlargement over it. The sesamoids of the big toes were not yet ossified. A linear density could be seen in the lateral view of both feet in place of the talonavicular joint which failed to develop. Marked planus deformity was also demonstrable. (See Figures 2-A and 2-B.) The roentgenograms of the patient's hands revealed nothing unusual. The mother's feet were normal on clinical examination, but, unfortunately, no roentgenograms could be obtained.

The patient was admitted to the Hospital and, on March 27, 1937, under general anaesthesia, the projecting parts of the talonavicular bones were shaved off. There was no definite subcutaneous bursa found during the operation.

The pathological examination of the removed bone revealed normal bone structure and was reported by Dr. H. Jaffe as showing "nothing illuminating".

The patient made an uneventful postoperative recovery. When seen in follow-up, about nine months after the operation, she stated that her feet gave her no discomfort. The planovalgus deformity, of course, was still present.

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TREATMENT OF BIRTH FRACTURES OF THE FEMUR

BY WILTON H. ROBINSON, M.D., PITTSBURGH, PENNSYLVANIA

This fracture occurs so rarely that when it does there is usually lacking an appliance for proper efficient treatment. Since the time when Credé recommended bandaging the broken leg to the front of the infant's body, many types of splints and appliances have been used. Silver was among the first to suggest an appliance for overhead traction. He modified the Bradford frame by adding a vertical post surmounted by a short horizontal piece to which the leg was suspended. Sir Robert Jones advised the Thomas splint. Fiske has used an inclined plane with weight traction. Schanz recommends an appliance which incorporates a heavy vertical wire (resembling a Thomas splint) into a posterior plaster shell. Rydén uses the same principle, but in his apparatus the vertical member is a Z-shaped piece with a pulley for weights on the upper horizontal part.

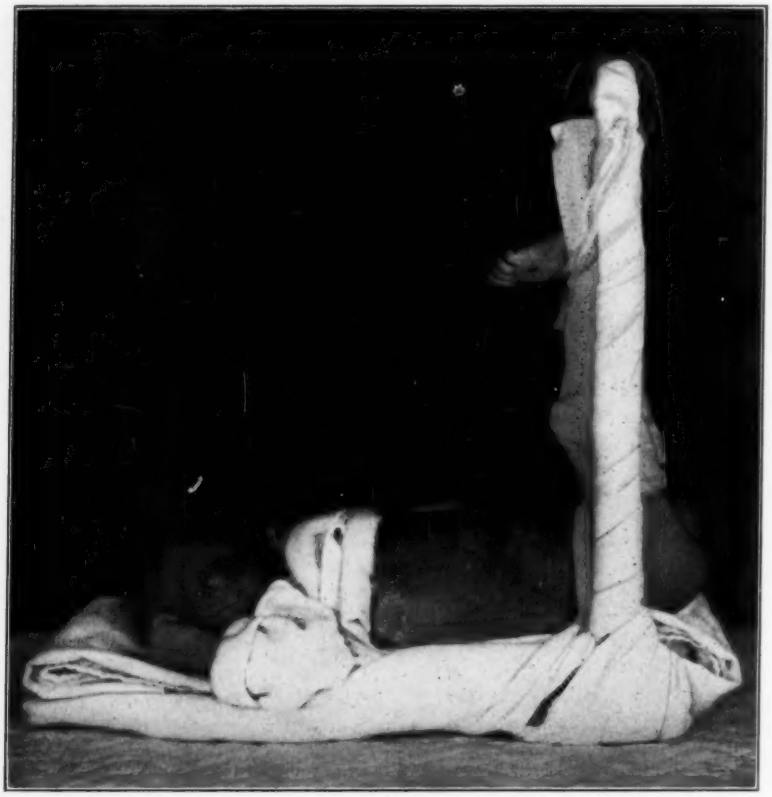

FIG. 1

Overhead traction splint. Note the piece of sheet lead on the child's abdomen to increase the amount of pull on the legs.

The splint herewith described was suggested by one shown in Truesdell's book on birth fractures. The only objection to Truesdell's appliance is that it is made of wood and it is somewhat cumbersome and inconvenient, particularly for nursing; nevertheless, it seems to embody the correct principles for the treatment of this fracture.

The splint which has been devised by the author is lighter and more convenient; it is constructed of materials and with tools which are available almost anywhere; and it can be made to the exact dimensions of the patient in a very short time.

The materials required consist of one piece of heavy tin or aluminum of moderately heavy gage; one piece of strap iron, three-eighths or one-half of an inch thick and about forty inches long; and four short bolts, one-eighth of an inch in diameter, and nuts or rivets. The only tools which are necessary are a pair of tin shears, a hand or electric drill, and a hammer.

FIG. 2

Overhead traction splint. Note that the patient's buttocks are suspended above the surface of the bottom of the splint.

The infant is laid on the sheet of tin or aluminum with the buttocks at one edge, and the tin is marked with a pencil where the sides are to be bent up. Another pencil mark at right angles is made one inch beyond the head. The patient is then removed, and the sides of the sheet are turned up and cut off, so that they are two inches high. The upper six or eight inches of the sides are trimmed down to a height of one inch. All corners are snipped off or bent down. The strap iron is bent into rectangular form and, after holes have been drilled, it is bolted to the tin at its lower end at an inclination of about 10 degrees toward the top. Moleskin adhesive straps are applied to both of the patient's legs in the usual manner. The appliance is padded, and the padding is held in place by a bandage which, for the sake of appearance, is also continued

over the extension member. The patient is then placed on the appliance with the buttocks suspended about two inches and with both feet on the same level. In the case of a light-weight infant, a piece of padded sheet lead may be placed over the abdomen to give additional traction. If more than the countertraction of the child's body is desired, a pair of pulleys may be attached to the top of the overhead frame, so that the traction cords may be attached to weights or elastic traction may be placed at the side of the uprights.

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A CAP TO PROTECT THE ENDS OF STEINMANN PINS

BY ROBERT MAZET, JR., M.D., OYSTER BAY, LONG ISLAND, NEW YORK

It has been apparent for some time that the usual methods of protecting hands, clothing, and bedclothes from the sharp points of Steinmann pins by placing corks over their ends, or by winding plaster about them, are not completely satisfactory. Corks invariably come off, and plaster is unsightly and difficult to remove entirely when one wishes to withdraw the pin.

We have been using on the Orthopaedic Service of the Meadowbrook (Nassau County) Hospital for six months the cap shown in Figure 1. It has proved itself eminently satisfactory from the viewpoint of nurses, patients, and surgeons. It is simply made and easily applied; it gives adequate protection; it does not come off; and it is readily removed by the surgeon, leaving a clean end to be passed through the tissues on withdrawal of the pin. It also prevents the point of the pin from being dulled by contact with hard objects.

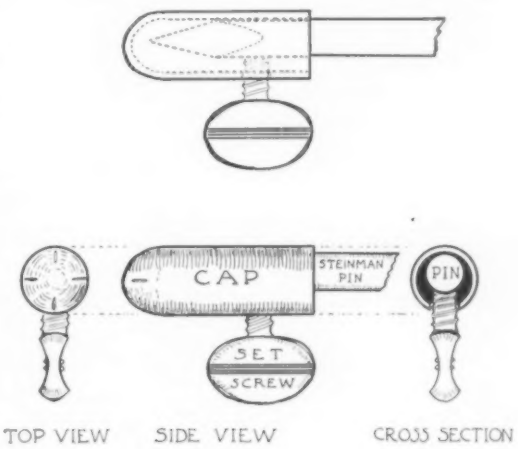

FIG. 1

The caps are made by the Engineering Department of the Hospital from brass rods in two sizes, the inner diameters being four and five-tenths millimeters and seven millimeters. The smaller caps are three-fourths of an inch in length; the larger, one inch in length. The brass rods are cut in sections a little longer than the desired length, and one end is then hammered closed. (Some of the caps have been made by cutting the rod the desired length and closing one end with solder.) A hole is drilled near the open end and threaded, and a set screw is fitted to the thread.

The open end is placed over the point of the Steinmann pin in the operating room, and the set screw is firmly tightened. The cap remains in place until unscrewed by the surgeon when it is time to remove the pin.

A LEG HOLDER FOR HIP NAILING

BY ROBERT CRAWFORD ROBERTSON, M.D., CHATTANOOGA, TENNESSEE

On numerous occasions the author has felt the need for mechanical fixation of the extremities during "blind" hip-nailing procedures. Leg-holding by assistants has in several instances resulted in change of the angle of femoral rotation to such a degree that accurate insertion of the nails has been difficult, and the operation has been needlessly prolonged. To meet this need, the apparatus shown in Figures 1 and 2 has been devised. It has proved so satisfactory that it is reported with the hope that it may be of value to others.

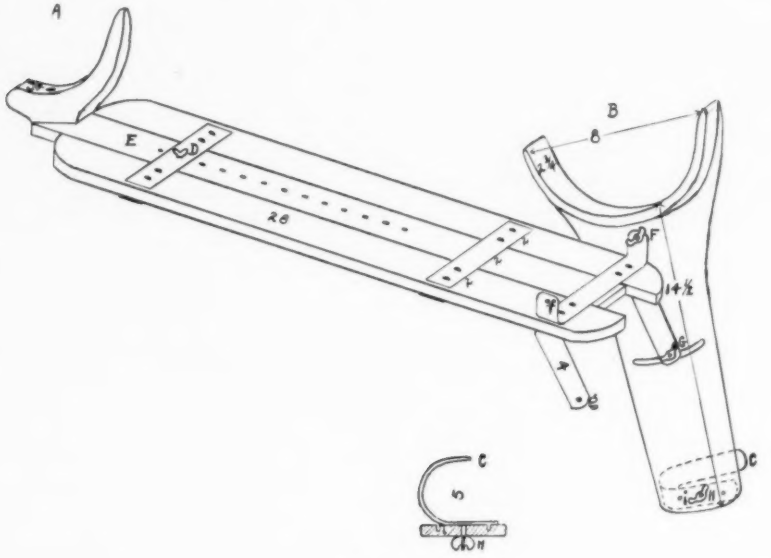

FIG. 1

Working drawing of leg holder assembled for nailing of the right hip, seen from above and from the right rear. Insert shows cross-section through half band of the leg. Dimensions given are in inches.

The holder is made of wood, three-quarters of an inch thick, and strips of strap iron one inch wide. It is placed across the stretcher or operating table with the stirrups *A* and *B* immediately proximal to the level of the knee joints of the patient. Preceding reduction of the fracture, the uninjured hip is completely abducted with the knee flexed at 90 degrees over stirrup *A*. This partially fixes the pelvis, which is further fixed by an assistant during the manipulative reduction. Following reduction, the desired angle of abduction is maintained by placing removable pin *D* in the desired hole in the sliding bar *E*, while the desired angle of internal rotation is maintained by rotating stirrup *B* at pivot *F*

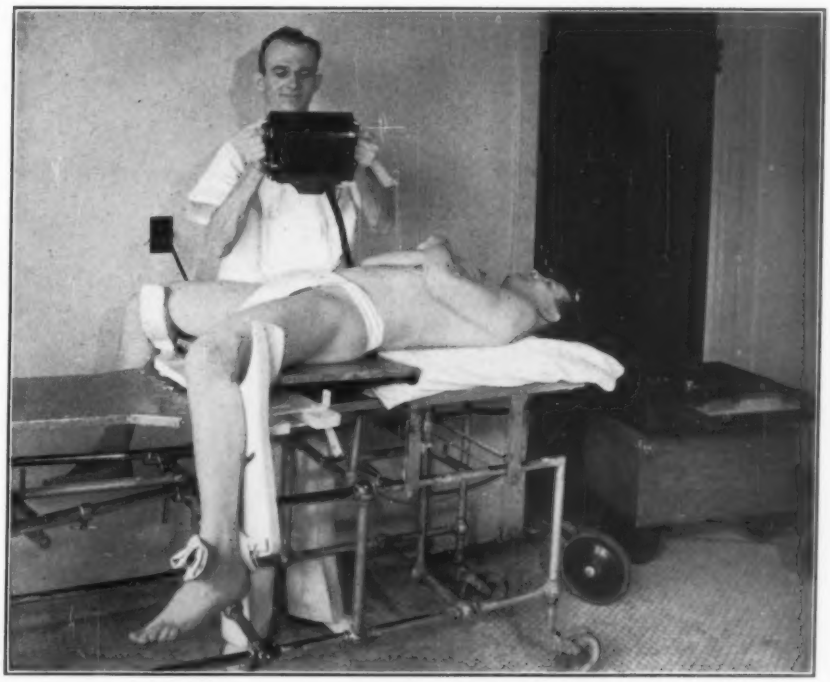

FIG. 2

Leg holder in use (without drapes), showing portable x-ray for anteroposterior view of the left hip. Vertical views are easily taken without change of position by placing the cassette against the lateral side of the thigh and the pelvis, with oil-immersion tube between the abducted thighs.

and locking with wing nut *G*. The knee of the fractured side is then flexed at 90 degrees over stirrup *B*, and the leg is engaged in the semicircular holder *C*. The supporting surfaces of stirrups *A* and *B* are wide, and, together with holder *C*, are heavily padded while in use. Either one or both of the extremities may be easily freed, or their position changed as desired. No interference is offered to portable roentgenograms made in "both views", or to operative procedure on the hip.

For use on the opposite extremity, the wing nuts *F* and *G* are unscrewed, and their bolts, together with the wooden attachment, are removed and reinserted through holes *f* and *g*. The wing nut *H* is loosened; holder *C* is rotated through an arc of 180 degrees and its locking pin is engaged in hole *i;* and the wing nut is tightened. Stirrup *A* is pivoted and may be rotated to the desired angle.

The holder is so constructed that both stirrups and the half band of the leg can be disjointed for transportation. Its construction is simple, and it can be made by any good mechanic.

The author is indebted to Mr. Omar W. Arnold, Chief Engineer of Baroness Erlanger Hospital, for the technical skill employed in constructing this device.

ORTHOPAEDIC SURGEON'S UTILITY AND PLASTER CART

BY VOIGT MOONEY, M.D., PITTSBURGH, PENNSYLVANIA

The accompanying illustrations show a utility and plaster cart which has been used with much satisfaction by the author in the Allegheny General Hospital, Pittsburgh. These two views of the cart give a hint as to its usefulness and to the economy of space when it is closed. It measures forty-four inches by sixteen and one-half inches by forty-five and one-half inches, and is constructed from 26-gage sheet metal and one-inch angle iron.

Because of its compactness and arrangement, it makes for greater efficiency and affords economy of motion on the part of the operator. The fact that it may be closed and locked assures one that the supplies contained therein will be available when next needed. Its movability provides an added feature in that it may be shifted easily from one operating room to another.

The cart contains the following standard equipment and usual materials employed in the application or removal of a plaster-of-Paris cast:

1. Two cast knives.
2. One cast-knife sharpener.
3. One cast spreader and brace wrenches.
4. One pair of heavy-felt scissors.
5. Two pairs of bandage scissors.
6. A large piece of black felt.
7. A silence cloth cut in strips, four inches by thirty inches.
8. Wooden wedges for spreading casts.
9. Large corks and a variety of small nails.
10. Wooden tongue depressors and applicators.
11. Four pine plaster boards, nine inches by four inches by one-quarter of an inch.
12. One syringe for moistening casts.
13. Petrolatum to grease attachments to the Hawley table.
14. Two Allegheny-metal buckets (three and one-half gallons, each).
15. Sheet wadding:
    Six inches by six yards.
    Four inches by six yards.
16. Plaster-of-Paris bandages:
    Six inches by six yards—weight, ten ounces.
    Four inches by six yards—weight, eight ounces.
17. Gasoline, ether, alcohol, and tincture of iodine.
18. Ichthyol and collodion.
19. Mercurochrome (aqueous solution) 5 per cent.
20. Gauze, muslin, and flannel bandages.
21. Roll of adhesive tape.

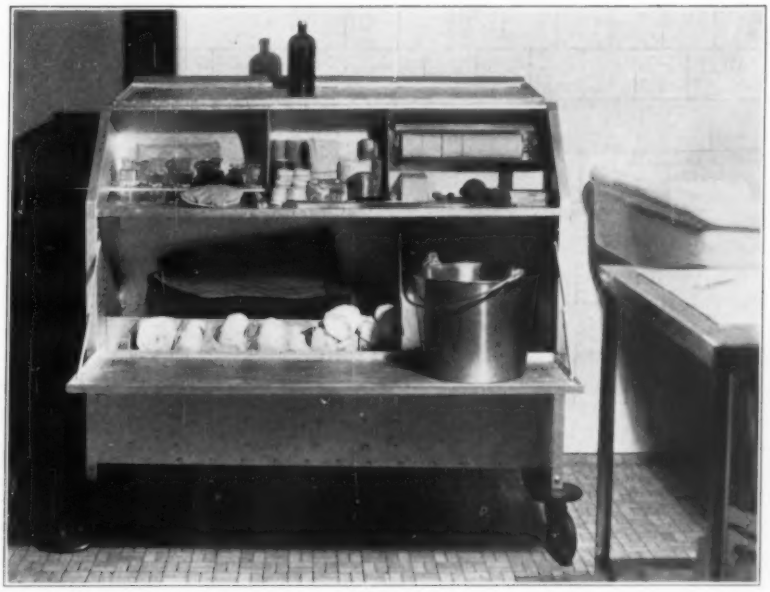

FIG. 1

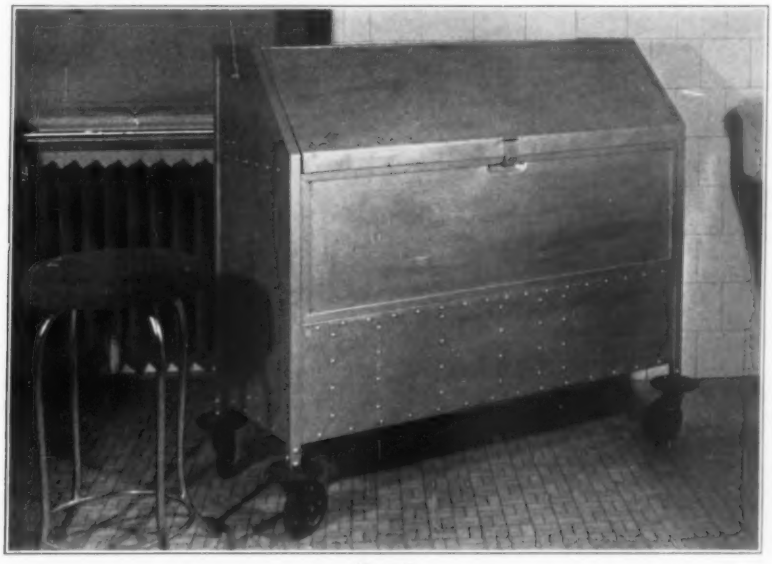

FIG. 2

22. Three different sizes of safety pins.
23. Talcum and stearate-of-zinc powder (one can of each).
24. Dressings and sterile applicators.
25. Rubber sheet and pillow.
26. Tape measure.

This list is affixed to the interior of the cart where the nurse in charge may consult it and quickly replenish the used supplies.

A PIN AND STIRRUP FOR FINGER AND TOE TRACTION

BY EDWARD N. REED, M.D., F.A.C.S., SANTA MONICA, CALIFORNIA

When fingers or toes present compound fractures or fractures and contaminated open wounds, it is often necessary to apply traction which will not interfere with the treatment of the open wound. Such traction is best applied by a wire passed through the pad of the terminal phalanx. When a flexible wire is used, it produces discomfort from pressure on the sides of the pad; it also causes a marked atrophy of the pad, if the traction is kept up for several weeks,—probably because of the ischaemia produced by the lateral pressure of the wire. Several cases have been observed in which this atrophy is apparently permanent, and it is quite unsightly.

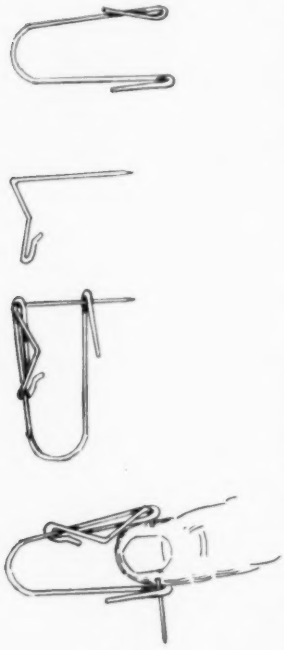

FIG. 1

Where a stiff wire or pin is used, which does not sag and so produce lateral pressure, the traction is not extremely uncomfortable and atrophy of the pad is not so apt to occur. Stirrups for connection between the pin and the traction rubber are readily made of wire and have long been in use. The difficulty with using them is to fix the pin in the stirrup so that it cannot slip sidewise and become disengaged from the stirrup. Adhesive has been used to wrap the ends of the pin, but this is apt to slip off; moreover it is cumbersome to apply in the small space available, and becomes fouled with discharges from infected wounds, making it difficult to keep the dressing sterile.

The pin and stirrup here illustrated overcome these difficulties. The straight end of the pin has a three-sided point ground on it, which readily pierces the pad. The other end of the pin has a loop which snaps over the side of the stirrup and which will not come undone except by a deliberate attempt. This snap loop, together with the angular bend in the short arm of the pin, prevents lateral slipping in either direction. After the pin has been inserted through the pad, the stirrup hooked over it, and the pin snapped in place, the pointed end is cut off with a wire cutter a little beyond the stirrup.

Both pins and stirrups are made of silichrome steel wire (18–8 stainless, hard drawn, 50/1000 of an inch thick), such as is used for making Kirschner wires. The snap loop is bent so that the entrance is a little narrower than the diameter of the stirrup wire, beyond which narrow neck the end of the wire flares out a little. The wire is very springy and the loop can be snapped onto the side of the stirrup by firm pressure and will remain in place until reverse pressure is put on it.

News Notes

The Fifty-Second Annual Meeting of the **American Orthopaedic Association** was held at the Ambassador Hotel, Atlantic City, New Jersey, on May 2, 3, 4, and 5, under the presidency of Dr. Frederick C. Kidner. This meeting was held in conjunction with the Fiftieth Congress of American Physicians and Surgeons, since the American Orthopaedic Association is one of the component organizations.

With only slight changes, the program as published on page 514 of the April issue of *The Journal* was followed. Mr. T. P. McMurray, of Liverpool, was the guest of honor and presented an important paper on "Osteo-Arthritis of the Hip".

The Annual Dinner of the Association was held on Wednesday evening, May 4, and the reception for members of the Congress took place on Tuesday evening, May 3. Joint sessions with the Congress were held on Tuesday evening and on Wednesday afternoon.

The Association met in Executive Sessions at noon on Tuesday, May 3, and Thursday, May 5, when the business of the Association was transacted.

Elected to active membership in the Association were the following:

E. J. Berkheiser, M.D., Chicago, Illinois.
Edwin F. Cave, M.D., Boston, Massachusetts.
C. H. Crego, Jr., M.D., St. Louis, Missouri.
Herman F. Johnson, M.D., Omaha, Nebraska.
Sumner M. Roberts, M.D., Boston, Massachusetts.

Dr. Frank D. Dickson, Kansas City, was chosen President for the year 1939–1940.

The officers for 1938–1939 are as follows:

President: William Ward Plummer, M.D., Buffalo, New York.
President-Elect: Frank D. Dickson, M.D., Kansas City, Missouri.
Vice-President: W. Barnett Owen, M.D., Louisville, Kentucky.
Treasurer: John L. Porter, M.D., Evanston, Illinois.
Secretary: Ralph K. Ghormley, M.D., Rochester, Minnesota.

The following Members of Committees and Delegates were elected:

Member of Membership Committee: Edward L. Compere, M.D., Chicago, Illinois.
Member of Program Committee: Alan DeForest Smith, M.D., New York, N. Y.
Representatives on the American Board of Orthopaedic Surgery: George E. Bennett, M.D., Baltimore, Maryland, and Charles W. Peabody, M.D., Detroit, Michigan.
Delegate to the American College of Surgeons: James Archer O'Reilly, M.D., St. Louis, Missouri.
Delegate to the Congress of American Physicians and Surgeons: J. Torrance Rugh, M.D., Philadelphia, Pennsylvania, re-elected.

Dr. Leo Mayer has moved his office from 140 West 79th Street to 1150 Fifth Avenue, New York City.

Dr. Richmond Stephens announces the removal of his office to 333 East 43rd Street, New York City.

Dr. Athey R. Lutz has opened an office at 1044 Market Street, Parkersburg, West Virginia.

The Journal regrets to record the death of Prof. Hermann Gocht in Berlin, on May 18. Dr. Gocht was Professor at the University of Berlin and also held the position of Director of the *Oskar-Helene Heim*, formerly occupied by Prof. Biesalski. He was an active member of the Deutsche Orthopädische Gesellschaft. The passing of Prof. Gocht is a great loss to the profession.

The Annual Meeting of the **Czechoslovakian Orthopaedic Society** will be held in Prague on July 8 and 9, in conjunction with the Pan-Slavonic Medical Congress and the Pan-Sokol Railly.

"Public Health in the World of Tomorrow" is to be the general topic of the Sixty-Seventh Annual Meeting of the **American Public Health Association** to be held in Kansas City, Missouri, October 25–28. Information about this meeting may be obtained from the American Public Health Association, 50 West 50th Street, New York, N. Y.

The next examination of the **American Board of Orthopaedic Surgery** will be held in conjunction with the meeting of the American Academy of Orthopaedic Surgeons, at Memphis, Tennessee, in January 1939.

Applications for this examination must be filed on or before October 15, 1938, with the Secretary, Fremont A. Chandler, M.D., 6 North Michigan Avenue, Chicago, Illinois.

The **Australian Orthopaedic Association** held its first Annual Meeting in Sydney, Australia, March 21 and 22, 1938. This marks the organization of the orthopaedic surgeons in Australia, and *The Journal* sends greetings and congratulations to this new Association, with best wishes for the future.

The **Fourth World Conference of Workers for Cripples** will be held at Bedford College, Regent's Park, London, July 16–22, 1939, under the auspices of the Central Council for the Care of Cripples. Information about the Conference may be obtained from The Organising Secretary, Mr. M. Blennerhassett, 34, Eccleston Square, London, S.W.1, England.

The report of the work of the **Palestine Society for Crippled Children** for the year 1937, just received, indicates the valuable contribution which that Society is making. Through the Clinic, the School (under the auspices of the Women's Auxiliary), and the Social Service Department, help is being given to the crippled children of Jerusalem. The Medical Director of the Society is Dr. Henry Keller, of New York. A branch has been opened in Haifa, and plans for the future include another branch at Tel Aviv and an Orthopaedic Hospital in Jerusalem.

At the **Réunion d'Orthopédie et de Chirurgie de l'Appareil Moteur de Bordeaux,** held on March 24, 1938, under the presidency of Dr. Edouard Papin, the following papers were presented:

Surgical Treatment of Fractures of the Epitrochlea in Children—Dr. Charles Lasserre and Dr. Dotézac.

The Phelps-Salaverri Operation in Talipes Cavus—Dr. H.-L. Rocher and Dr. Robert Guérin.

Several Cases of Marked Rachitic Deformity: Pott's Disease. Scoliosis with Pigeon-Breast Deformity—Dr. H.-L. Rocher and Dr. Robert Guérin.

Malformation of the Vertebrae with Displacement of the Scapula—Dr. Robert Guérin.

Auricular Disturbances in Paget's Disease. A Clinical and Anatomopathological Study—Dr. Charles Lasserre and Dr. R. Philip.

Maldevelopment of the First Portion of the Tarsometatarsal Joint (Great Toe) with Phalangeal Clinodactyly. Malformation of the Supplementary Portion—Dr. H.-L. Rocher and Dr. Robert Guérin.

Some Special Aspects of the Femoral Head after Treatment of Congenital Luxation—Dr. H.-L. Rocher and Dr. L. Pouyanne.

The next president of the Society is Dr. Charles Lasserre.

THE INTERNATIONAL CONGRESS ON RHEUMATISM AND HYDROLOGY

London and Oxford, March 25–31, 1938

The Congress opened in London with a reception given by His Majesty's Government at Lancaster House and a tea at the "Practitioner". About 200 members from twenty countries were present. Visits were made to the West Wickham and Carshalton Hospitals and to the St. John's Clinic and the British Red Cross Clinic for Rheumatism.

At Oxford, the medical discussions began with a symposium on the relationship between climate and disease. It was agreed that the damp, variable climates show the highest frequency of rheumatic diseases in Europe, in spite of the fact that the northern seacoast countries show the greatest number of people living above eighty years of age. In Sweden one finds a certain parallelism between the barometer variability and the percentage of frequency of rheumatic fever, as well as the percentage of people over ninety years of age. According to Prof. De Rudder, it can be stated definitely that the weather changes act on the organism by the way of the sympathetic nervous system. The typical picture develops in the young of certain families after acute streptococcal infections of the upper respiratory tract. There is a silent period of from seven to twenty-one days before the true rheumatic manifestations appear. The sedimentation rate suggests coccal etiology rather than a virus. Prof. Gibson believes that allergy may be a late phenomenon, as in syphilis. The general opinion was that the rheumatic state in children is progressive, chiefly in the heart and the aorta, and is permanent. Prof. Klinge differentiated clinical rheumatic fever (joint symptoms with heart involvement) from polyarthritis, which is rare, and Still's disease, which is quite different. Dr. Eagles suggested that the streptococcus alone cannot produce rheumatic fever; since 1935 he has considered the infecting agent to be a streptococcus with a virus. Seventy-two per cent. of the children with rheumatism have some heart involvement; mild carditis is present in 65 per cent. The prognosis is unfavorable. Medical treatment consists of rest in special country homes, as the convalescence should be prolonged. The treatment for prevention of deformity gives extremely good results. The interval of from one to four weeks which elapses between the infection and the attack is important and efficient treatment should begin at this period. It was agreed that rheumatic fever is a great evil to society. The opinion of the Congress was that rheumatic fever is probably caused by an infection from the throat; that hereditary factors, cold dampness, overcrowded conditions, undernourishment, and nervous strain aggravate the infection; and that the treatment should be directed toward these factors with the hope of prevention.

The Congress then left for Bath to attend the International Conference at that Spa.

INTERNATIONAL CONFERENCE ON RHEUMATIC DISEASES

Bath, March 31–April 3, 1938

The scientific sessions of the Congress were somewhat disappointing to an orthopaedic surgeon, because a whole day was given up to a series of papers on gout, although

every speaker agreed that it is a disease of steadily diminishing incidence and numerically is now of minor importance. However, several authorities maintained that its peculiar features are no better understood now than they were at the time of Sydenham's classic description. The chairman of the Section on Gout, Prof. F. R. Fraser, suggested that already the biochemists have provided all the bricks for the explanation of this mysterious disease, and it only awaits the genius of an architect to put them together. It was agreed that the relief came from those agents which increase elimination rather than destroy uric acid and that the gouty patient suffers from congenital or acquired difficulty in excreting purins. Determinations of uric acid of the blood are important. There may be chronic rheumatism of gouty origin, particularly osteo-arthritis of the knees and of the lumbar spine. There is a hereditary factor, possibly a transmitted allergic state, and there is also a gouty fibrositis. Prof. Gibson found that of the patients with true gout 11 per cent. were women and 24 per cent. had a familial history of gout; also, the onset was acute with complete intermission in 75 per cent. of the cases. An injury, infection, or worry preceded gouty attacks, as in other rheumatic conditions. He believes that gout is a form of rheumatism which takes place in a person with a particular defect in metabolism. The sedimentation rate is increased in 59 per cent. of the patients with gout.

Only a short morning session was given to the urgent subject of rheumatoid arthritis, and in this no reference was made to its orthopaedic aspects—such as the prevention of deformity, or the place of splinting in its treatment—or to the admirable effects of occupational therapy in increasing the morale and physical independence of sufferers, even in neglected cases. Three very interesting papers were given, but the limited time only allowed a narrow approach to a great subject and cut out nearly all discussion. Dr. Pemberton gave an interesting account of experimental studies of the circulation in arthritics, showing that in 75 per cent. the peripheral circulation had a lowered response to changes in external temperature and also decreased rates of tissue exchange, particularly for glucose and oxygen. Associated with these was accumulation of fluid in the tissues, possibly due to increased permeability of the capillary walls. He suggested that there are many circulatory deficiencies in arthritis produced by certain primary agents, but that some of the symptoms could be referred to the circulatory changes which are at first functional, shown in decreased rates in exchange of materials between tissues and blood, as evidenced in the low metabolism, decreased sugar removal, increased percentage of saturation of intravenous blood with oxygen, and increased range of vasomotor response following exposure of the body to low temperatures. Therapy should be directed toward these deficiencies and emphasis placed on the broad approach to the patient as a whole. Dr. Hench read a paper on the physiological effects of jaundice. Striking cases were described in which intercurrent attacks of severe jaundice, artificially produced, had resulted in remission or temporary cure of rheumatoid and fibrositic changes, although the latter had tended to relapse after the jaundice had subsided, the period of relief being two or three times the length of the attack of jaundice. Regardless of the supposed validity of the infection theory, rheumatoid and fibrositic changes can be profoundly influenced by a phenomenon primarily chemical. Prof. Davidson pleaded for an organization like that which has been so successful in Britain in dealing with crippling conditions in childhood,—that is, new central hospitals associated with scattered clinics, the latter staffed by trained specialists paid by the State. He recognized that sufficient numbers of such specialists are not available at the present moment and he pleaded for a postgraduate school for their education. He did not call attention to the fact, however, that a considerable number of the cases, which the profession at large calls "rheumatic" and which swell the government statistics, are already receiving satisfactory treatment in the present orthopaedic clinics and hospitals.

BRITISH ORTHOPAEDIC ASSOCIATION

The Spring Meeting of the British Orthopaedic Association was held in London and Oxford on May 27 and 28 under the presidency of Mr. Naughton Dunn. There were a

large number of guests from the Scandinavian countries, among them Dr. Guildal of Denmark, Prof. Waldenström of Sweden, and Dr. Plato of Norway. The Association Dinner was held at the Langham Hotel, at which, in addition to the Scandinavian guests, there were present Prof. Maffei of Brussels and Dr. Leveuf of Paris. There was also a dinner in New College, Oxford, at which Viscount Nuffield was present and addressed the Association.

One whole day was spent at the country branch of the Royal National Orthopaedic Hospital at Stanmore, and at the Wingfield Morris Hospital at Oxford. Clinical demonstrations at both hospitals covered a wide range of deformities and diseases, tuberculous and non-tuberculous. The excellent departments for occupational training aroused great interest.

During the Meeting the following short papers were presented:

Distribution and Treatment of Extra-Articular Foci in Tuberculous Arthritis of the Hip Joint by Mr. J. A. Cholmeley, London.

The case histories of fifty-five children, treated for tuberculous foci in the neighborhood of the hip, at the country branch of the Royal National Orthopaedic Hospital, were carefully reviewed. In forty-three patients conservative treatment had been employed and in twelve the focus had been excised. In a large majority of the cases, the hip joints became involved eventually, and less than 10 per cent. of the children escaped with movable hip joints. The conclusion was drawn that attempts to excise extra-articular foci had no advantages over conservative treatment.

Structure and Function in Synovial Joints by Mr. M. A. MacConaill, Sheffield.

In this paper Mr. MacConaill elaborated the remarks which he had made to the Association in October on the principles of Joint Mechanics. He outlined the relation and adaptation of joint function to its lubrication—the synovial fluid—and gave a detailed account of the structure and function of ligaments. He ended by describing several joints in detail in the light of his researches. Mr. MacConaill has stimulated great interest in this problem.

Osteochondritis of the Adult Tarsal Scaphoid by Mr. J. F. Brailsford, Birmingham.

This paper gave details of nine cases of osteochondritis of the scaphoid occurring in adult women, and affecting both feet. The characteristic lesion is an oblique splitting of the scaphoid and separation of the two fragments. The outer smaller fragment is displaced dorsally; the inner larger fragment displaces gradually and comes to lie on the *mesial* aspect of the head of the astragalus. Subsequently, gross osteo-arthritic changes develop in the midtarsal joint.

An Operation to Restore Opposition of the Thumb by Mr. F. G. Allan, Birmingham.

Mr. Allan reviewed the histories of forty-three patients on whom he had operated to restore opposition of the thumb. The procedure consisted of inserting a tibial graft between the index and thumb metacarpals so that the thumb was maintained at right angles to the palm. The operation was applicable to both flaccid and spastic paralyses. Very marked improvement in the function of the hand resulted in all but one of the patients.

Arterial Occlusion in Relation to Volkmann's Contracture by Mr. D. L. Griffiths, Manchester.

From a review of the literature and of clinical material, and from his experiences with emboli, Mr. Griffiths argued that the "venous obstruction" theory was no longer tenable as a cause of Volkmann's contracture, and that the bulk of the evidence was in favor of arterial obstruction. He cited two cases in which, following occlusion of the femoral artery by a proved embolus, changes, in every way similar to those associated with elbow and forearm fractures, occurred in the calf muscles. A plea was made for a more careful recording of these cases, especially such facts as the presence or absence of the radial pulse. Mr. Griffiths considers it likely that the only effective treatment is operation, which should include liberal opening of the deep fascia and inspection of the brachial

artery. Periarterial sympathectomy and arteriectomy have in the main been disappointing.

A Preliminary Account of a Method of Arthrodesis for Healed Tuberculosis of the Hip by Mr. H. A. Brittain, Norwich.

The operation, illustrated by a film, consists in performing a short oblique subtrochanteric osteotomy, displacing the distal fragment inward until its upper end comes into contact with the ischium over an area which is "rawed" with a special osteotome. If the hip is adducted, the procedure can be carried out "blindly" through a limited anterolateral approach. If abducted, the classical posterior approach is employed. It is claimed that this "ischio-femoral arthrodesis" is a much sounder mechanical procedure than the usual ilio-femoral arthrodesis. In either approach, the operation can be performed well away from the diseased joint. Reports were given on eight patients who had been observed for at least two years since operation. The functional results were excellent and there had been no recurrence of the disease.

CORRECTION

Our attention has been called to the fact that in the article entitled "A Bone Plate Which Will Not Break or Bend" by Dr. George W. Hawley and Dr. Ralph D. Padula, published in the April issue of *The Journal* (Vol. XX, page 469), reference should have been made to the following:

Souttar, H. S.: A Method for the Mechanical Fixation of Transverse Fractures. Ann. Surg., LVIII, 653, 1913.

Speed, Kellogg: A Discussion of Pott's Fracture with Complications: Based on a Series of 208 Cases. Surg. Gynec. Obstet., XIX, 73, 1914.

Speed, Kellogg: A Text-Book of Fractures and Dislocations with Special Reference to Their Pathology, Diagnosis and Treatment. Ed. 1. Philadelphia, Lea & Febiger, 1916.

The authors wish to acknowledge the priority of the principle of the flange plate which is presented in these articles. The omission of reference to them was entirely due to an oversight and is regretted by the authors.

Current Literature

DIE ERNÄHRUNGSBEHANDLUNG IN DER CHIRURGIE (Dietotherapy in Surgery). Dr. Arno Siller. (Vorträge aus der praktischen Chirurgie, 21. Heft.) Stuttgart, Ferdinand Enke, 1938. 2.20 marks.

In this monograph of forty pages, Dr. Siller, physician in charge of nutrition at the Institute in Isny of the Surgical Clinic of the University of Munich, describes the attempts that have been made to influence the course of surgical tuberculosis through diet. This work received impetus through the early studies of Gerson who believed that the pathological conditions in chronic inflammatory disease could be modified by special feeding; particularly, that an abundance of sodium chloride was harmful. Gerson taught that wounded tissues heal better with an acid nutritional status than with an alkaline one. It is mentioned as a point of interest that Hippocrates advocated fasting for wounded persons, but permitted the drinking of water and vinegar. Hermannsdorfer observed in the last year of the World War, when meat was rare in the soldiers' rations and vegetables were used in abundance, that the healing of wounds was slower and that secondary infection of wounds, especially with the diphtheria bacillus, was common.

Studies were made of the hydrogen-ion content, the diphosphate and ammonia of the urine, the carbon dioxide in the alveolar air, and the alkali reserve of the blood. (The results are not given.) Finkelstein and Czerny, in 1905, had found an acid-producing diet of value in certain of the exanthemata of children. From these studies and the author's experience, a diet, called the Sauerbruch-Hermannsdorfer diet, was devised. This diet allows about fifty calories per kilogram of body weight and is almost a normal mixed diet. It is particularly rich in protein and in fats. All meats, except smoked, salted, and those highly spiced, are permitted. Sodium chloride and conserves are forbidden. All vegetables and fruits, as well as eggs, milk, cheese, and butter, are given freely. In addition, vitamin concentrates are given,—in this diet, 45 grams of "*phosphorlebertran*" a day. This diet is given at seven periods during the day.

This acid-producing diet, free from sodium chloride but containing an adequate amount of minerals and vitamins, has been used in Lexer's Clinic since 1928. It is probable that its effect is expressed through the sympathetic nervous system and the endocrine system. The only data that the author could obtain on the effect of this diet in the course of tuberculosis were clinical data. The author has submitted a table of the end results obtained in 290 patients suffering from surgical tuberculosis who have been discharged during the last three and one-half years. The author attempts to determine a mean period of stay in the Institute for the various forms of tuberculosis. He states that the diet has aided in arresting all forms of surgical tuberculosis more quickly, particularly tuberculosis of the skin and of the supportive tissues. Case histories are given to show the clinical course in a few types of surgical tuberculosis. When the diet was used for patients suffering from visceral tuberculosis, only slight improvement was observed. It was questionable whether the diet was of any value in pulmonary tuberculosis.

Much interesting clinical observation is recorded in this book. The author has had the opportunity to observe the patients over long periods. Diets with acid or alkaline residue have been used before for many years with the hope that the tissues of the body would become a soil unfavorable for bacterial growth, or that reparative processes would be hastened. It is unfortunate that laboratory data of changes in the tissues could not be secured, but the clinical observations suggest that dietotherapy can be of definite aid in combating certain chronic infections.

PEDIATRIC SURGERY. Edward C. Brenner, A.B., M.D., F.A.C.S. Philadelphia, Lea & Febiger, 1938. $10.00.

This volume, according to the author's statement in the preface, is an attempt to produce a text, neither encyclopaedic nor compendial in type, which may be of practical

value to those engaged in the study and practice of Pediatric Surgery. "Fractures, dislocations, and other orthopaedic conditions" are omitted, but there are short chapters devoted to "Developmental Diseases of Bone", "Benign Bone Growths", "Sarcoma of Bone and Bone Marrow", and "Brachial Birth Palsy". These chapters are quite inadequate and could have been omitted without detriment to the book. The chapter on "Infections of Bone" is fairly detailed, but is far from being completely up to date. There is no differentiation of the course of the disease as it affects infants and older children, and the terms "streptococcus" and "staphylococcus" are not mentioned. The reviewer found the chapters on "Anaesthesia" and "Preoperative and Postoperative Regimen" well done.

The format of the book is attractive, the typography is excellent, and there are nearly 300 illustrations.

MASSAGE AND REMEDIAL EXERCISES IN MEDICAL AND SURGICAL CONDITIONS. Noël M Tidy. Ed. 3. Baltimore, William Wood and Company, 1937. $5.25.

In this third edition of "Massage and Remedial Exercises", the author has covered in a thorough manner a very large field. The book can be of value to those, and only to those, who are familiar with and have had experience with the principles and the applications of physiotherapy, and the author undoubtedly presupposes this training. She covers the entire field of surgery and medicine in which this therapy could be used and gives indications for its employment,—the existing conditions for which it is used and the indications for the choice of the form of massage and physiotherapy which should be applied in each.

Chapters are devoted to surgical conditions, fractures, dislocations, sprains, and various diseases. Under each subject is given a brief statement on the etiology, symptoms, and pathological changes, with an outline of the principles and methods of physical treatment for this condition.

Special attention has been given in this new edition to the revision of the sections dealing with the methods of treatment, that they may include the changes which have recently come and have been accepted by the medical profession.

Of just how much value the consideration of the pathology and the surgical or medical treatment is in a book of this scope, is questionable, for such a consideration must necessarily be fragmentary and a clear understanding of this phase of the subject cannot be gained. Since it is generally accepted that the physical treatment should be given only under the direction of a medical attendant, an incomplete understanding of the condition is frequently misleading.

The exercises to be used are very clearly described and particularly well illustrated, and the directions to guide in the choice of therapy will be helpful, even to experienced physiotherapists. The author has evidently had an extensive experience in this special treatment and she has presented exercises and movements which can be used successfully and which will enlarge the scope of most workers in this field. The book will be a valuable guide to aid in the adaptation of the methods of physiotherapy to the various conditions in the rather extensive field which is covered by this book.

DIE KRIEGSSCHUSSVERLETZUNGEN DER GELENKE UND KNOCHEN DER GLIEDMASSEN (World-War Gunshot Injuries of the Bones and Joints of the Extremities). Prof. Dr. Karl Franz. (Vorträge aus der praktischen Chirurgie, 18. Heft.) Stuttgart, Ferdinand Enke, 1938. 1.80 marks.

This monograph brings the experience of the World War to bear on the subject of open fractures of the joints and of the long bones. It sifts out and presents the treatment which resulted in a mortality only one-tenth as great as that due to similar injuries in the Franco-Prussian War of 1870. Franz emphasizes above all else the element of infection,—its prophylaxis during the first twenty-four hours, the rigid aseptic technique re-

quired for open injuries of joints, and at the same time the value of not too radical surgery in the early treatment of gunshot fractures of the long bones (fractures which in general are less susceptible to secondary infection than the compound fractures occurring in civil life). Subsequent treatment of secondary infection must consider not only the preservation of life, but also measures which will reconstruct the injured joint and avoid pseudarthroses, especially in the lower extremity.

The author upholds the antiseptic attack on infected joints. Frank infection demands irrigation and drainage; this is to be combined with periodic, maintained, closed distension of the joint with phenol, camphor, and alcohol solution; transient irrigation is unavailing. Bactericidal solutions must act continuously in a joint for from twenty-four to forty-eight hours to be effective. Progressing infection demands wide exposure and often joint resection.

Franz points out that, although gunshot wounds of bone constitute compound fractures, conservative expectant treatment is in order when entrance and exit wounds are confined to the size of the projectile; when these wounds are larger, they should be débrided and left open. The most important principle in early treatment is the minimal disturbance of injured tissues compatible with avoidance of infection. Moderate subsiding infection can be aided by the now much neglected progressive secondary suture. Salve, containing 1.5 per cent. silver iodide and cod-liver oil, is useful in later treatment. Serum prophylaxis against tetanus and gas-bacillus infection is necessary. Delayed hemorrhage is treated by proximal arterial ligature. Thrombophlebitis requires venous ligature or resection. Necessary amputations should be carried out soon.

In this monograph the types and treatment of secondary infection are particularly well handled. The author's sound knowledge of the complications associated with bone and joint injuries is transmitted to the reader in a way that provides an unusually clear perspective of a subject which is too seldom accorded such a useful presentation.

EMERGENCY SURGERY. Hamilton Bailey, F.R.C.S. (Eng.). Ed. 3. Baltimore, William Wood and Company, 1938. $14.00.

This is a comprehensive book on emergency surgery. It is a third edition of 817 pages, with 816 illustrations, of which a large number are in color. The subject matter covers a wide range and is concisely treated, and, for the most part, the space allotted to the various topics is adequate and proportionate to their importance.

The book opens with excellent chapters on intravenous therapy, blood transfusion, anaesthesia, and the ordinary tools necessary for emergency surgery. There follow a fairly extensive but extremely informative group of chapters on emergency abdominal surgery. There is a tendency at times to apply the terms *always* and *never* to conditions open to differences of opinion. However, there is so much of excellence, and the text is so profusely and well illustrated, that this book cannot fail to prove of value to the surgeon engaged in emergency abdominal surgery.

The chapters on bones and joints are good as far as they go. The treatment of compound fractures is covered adequately, but simple fractures are entirely omitted. Dislocations are well illustrated, as is the treatment of septic joints. However, the Carrel-Dakin and Orr methods are only mentioned briefly in their relation to the treatment of compound fractures. The chapters on "Nerves and Tendons", "Lacerations and Mutilations of the Hand", and "Infections of the Hand" are all good.

A very valuable chapter is that on "Urgent Amputations". The best levels for amputation under varying conditions and the operative techniques are given. The illustrations are plain and well done. The subject of artificial limbs is discussed.

The book covers nearly every conceivable emergency. Although the surgeon who is interested in emergency surgery may encounter in its pages an occasional statement not in accord with his belief, there is much of value in this book to recommend it.

DIE VITAMINE UND IHRE KLINISCHE ANWENDUNG. EIN KURZER LEITFADEN (Vitamins and their Clinical Application. A Short Guide). Dr. W. Stepp, Dr. J. Kühnau, und Dr. H. Schroeder. 3 Aufl. Stuttgart, Ferdinand Enke, 1938. 9.50 marks.

This book attempts to review the present-day knowledge of the vitamins, with their chemical formulae and the physiological effects which they produce. The popularity of the work in German-speaking countries is attested by the appearance of the third edition unchanged six months after the appearance of the second. There is a fairly exhaustive discussion upon the commonly known vitamins A, B, C, D, and E, with the subdivisions of vitamin B. A short discussion is given to vitamin H, apparently a protein, essential to normal function of the skin and active in metabolism of fats and proteins. Its chief sources are the liver and the kidneys of cattle and swine. It is present in small amounts in milk, potatoes, and bananas. The antihemorrhagic vitamin (factor T and vitamin K) is described. The absence of this vitamin or group of substances leads to a decrease in blood platelets. The T factor cannot be separated from fats and is associated with vitamin A. Vitamin K seems to be an oil soluble in alcohol, and to be present in most vegetables, particularly cabbage and carrots. The permeability vitamin, vitamin P, is mentioned briefly. It is usually associated with vitamin C and found when the less refined forms of vitamin C are given. Since many of the vitamins can be given in crystalline form, toxic effects from too large quantities are occasionally observed. A complete review of the world literature is given. The interrelationship of vitamin and mineral metabolism is discussed, but no conclusions are drawn. Many so-called vitamins may act as enzymes or as catalyzers. While the work is incomplete, since the experimentation and reporting of biological and chemical data concerning vitamins is progressing so rapidly, it is a sane, carefully weighed presentation of our present knowledge. It should be of great value to students in this field, especially for its carefully selected bibliography.

ATHLETIC INJURIES. PREVENTION, DIAGNOSIS AND TREATMENT. Augustus Thorndike, Jr., M.D. Philadelphia, Lea & Febiger, 1938. $3.00.

This compact little volume represents the results of the observation of a well-trained general surgeon at a large university, who has had a wide experience in handling traumatic injuries on the athletic field and through convalescence.

The history of the evolution of the methods at present employed at Harvard is first outlined. The factors that enter into the attainment of physical fitness, as determined by those who have devoted themselves to research in these matters, have been taken full advantage of in respect to the skeletal muscular system, the cardiovascular and respiratory systems, certain chemical and physical changes contributing to the efficiency of the trained athlete, and the central nervous system. Then follow three chapters on physical training, physical fatigue, and the prevention of injury. The remaining chapters deal with the injuries that befall the participants in the major sports and the treatments accorded them.

The text is well illustrated and furnishes the reader with a clear idea of what has been found to be best in the management of this kind of injury on the athletic field. The book should be in the hands of all who are called upon to treat cases of this type.

WUNDVERSORGUNG UND WUNDBEHANDLUNG (The Care and Treatment of Wounds). Prof. Dr. Hans von Seemen. (Vorträge aus der praktischen Chirurgie, 19. Heft.) Stuttgart, Ferdinand Enke, 1938. 4.20 marks.

This is another monograph of a series which provides excellent lectures for student or surgeon. Beginning with an outline of the history of and advances in the treatment of wounds, it describes the pathological foundation for the distinction between healing by primary and by secondary intention. The latter differs from primary healing quantitatively, whereby the larger space and greater tissue reaction allow greater opportunity for necrosis and infection. Operative incisions usually heal by primary intention; accidental

wounds by secondary intention. The purpose of excision and prompt closure of accidental wounds is to convert their healing to that of primary intention. The technique and mistakes of early operative treatment are carefully described. When body cavities, such as joints or pleural spaces, are opened, the correct principle is to close the cavities, but to drain the overlying tissues. In primary closure, great care must be exercised to prevent infection from the adjacent skin; silver foil is most useful in achieving this object.

A bacterial survey of infected wounds is given. Earth-borne infection is often anaerobic and frequently combatable by antisera. Surgical injury of old or infected wounds should be avoided as much as possible. Attempts at interstitial antisepsis are misdirected. It is important to promote drainage and tissue transudation; granulated sugar provides an excellent osmotic agent. When salves are used, they should possess a fat base saponifiable by wound secretions. Burns are to be treated by resection of necrotic tissue and electrocoagulation of burned surfaces. Although no antiseptic application is superior to primary excision, the time-honored Chlumsky solution (alcohol 10 parts, camphor 60 parts, phenol 30 parts) is valuable in the treatment of joint infections. Contractures, ankyloses, and plastic defects may be treated after infection subsides.

Systemic effects of wounds are associated with mensurable changes in the proportions of the blood elements. The resorption products of wounds are inactivated by a temperature of 59 degrees centigrade, a fact favoring electrosurgery. The author recommends this type of surgery because the coagulation incision minimizes tissue necrosis; there is little or no operative shock; it causes less hemorrhage, and fewer ligatures are necessary; no cell transference is present; there is little postoperative pain; and healing is accelerated.

An appendix gives a list of supplies, medication, and sera. In all, von Seemen's monograph gives a clear and thorough exposition of the application of the best surgical principles to the care and treatment of wounds.

American Medicine. Expert Testimony out of Court. Edited and Published by The American Foundation, New York, 1937. Two Volumes, $3.50.

This work, in two bulky volumes, is an admirable example of a type of research which has become increasingly familiar in America, which we may term "research by questionnaire". It was undertaken by The American Foundation in order to obtain a representative expression of opinion from selected physicians throughout the United States on a variety of controversial subjects relative to the part which government should play in regulating medical practice and providing adequate medical care to the citizens of this country. Approximately two thousand doctors participated, and this report presents a digest and summary of their "expert testimony out of court". The topics considered indicate the range and scope of the inquiry: organization of medical care; medical education; specialization; group practice; the place of the hospital; public health organization; experimentation; state medicine; health insurance; limited state medicine and private practice.

Naturally, from so wide a variety of contributors, unanimity or definitive conclusions are not to be expected. *Quot homines, tot sententiae.* Probably all these problems will ultimately be settled, as is the custom in human affairs, by the attrition of time and experience. Nevertheless, this carefully edited exposition remains a valuable record of contemporaneous opinion in the process of crystallization into decision.

Wetter und Jahreszeit in der Chirurgie (Effects of Weather and Season in Surgery). Georg Maurer. (Vorträge aus der praktischen Chirurgie, 20. Heft.) Stuttgart, Ferdinand Enke, 1938. 2.50 marks.

This monograph is not confined to surgical conditions, but gives a general survey of the relationship of meteorology to medicine, a relationship known to Hippocrates and appearing in statistical tables since 1770. It seeks explanation in the changes in tem-

perature and barometric pressure resulting from the contacts of different air currents, whose conflicting movements produce changes in the earth's electromagnetic field and create forces of various wave lengths in the atmosphere. Such alterations in electrical conductivity are believed to be transmitted by the human skin and lungs to the parasympathetic nervous system. In some individuals, certain physiological responses may be almost barometric in their constancy, but the variability in human and atmospheric factors leaves the subject on a more statistical than scientific basis. Even now, however, there is sufficient evidence of this relationship to permit a degree of prophylaxis at times of sharp changes in barometric pressure and in temperature, particularly the avoidance of elective major surgery on such occasions. Maurer's monograph is informative and stimulating; it possesses a good bibliography; and it is of especial value in calling attention to the frequent coincidence of numerous diseases and afflictions and typical weather changes. The author understands the present limitations of his subject and urges its further investigation especially in the study of individual cases. He emphasizes not so much the effect of weather on disease as the effect of weather on both healthy and diseased individuals.

INFECTIOUS DISEASES OF BONES, JOINTS, AND CARTILAGES. Prof. V. D. Chaklin. Sverdlovsk, Sverdlovsk Regional Publication, 1937.

This book, embodying the personal experience of the author, is written for the practical surgeon. It reflects a much wider knowledge of the American and foreign literature than has been observed in previous books received from the U.S.S.R.

The author limits the scope of his book to the consideration of acute and chronic streptococcus, staphylococcus, typhoid, paratyphoid, typhus, and mycotic infections. Due place is given to pathology and physiology and this is well balanced by a detailed and clear description of treatment. The author emphasizes the importance of conservatism as well as of careful operative treatment. The orthopaedic management of residual deformities, as well as the simultaneous application of orthopaedic treatment and the treatment of the acute or chronic infection, is well presented. There is a good index of subjects and authors,—rather a novelty in the Russian medical literature. The book will undoubtedly be valuable for the Russian surgeon.

ORTHOPÄDIE UND KINDERLÄHMUNG. Dr. Friedrich Mommsen. Stuttgart, Ferdinand Enke, 1938. 3.85 marks.

This monograph upon the treatment of infantile paralysis is the result of thirty years of study and treatment of this disease at the *Oskar-Helene Heim* near Berlin. The monograph is dedicated to Konrad Biesalski with whom the author was associated until the death of Biesalski in 1930.

While there is little new in the book with the exception of ingenious but simple apparatus for the prevention of deformities, a broader point of view than is usually taken in this disease is frequently shown. The author stresses what he calls "sociobiological rehabilitation". By this he means that treatment and operative procedures are all planned with due consideration of the patient's capabilities and permanent physical handicap. The treatment should have as its aim not merely or always the purely orthopaedic treatment, but the fitting of the individual into that place in society which he can best fill. The methods of examination of muscle function are discussed, but no method of grading muscle strength is given. Exercise and active and passive redressement are discussed, but no statement is given as to when to use them and when not to use them. Early weight-bearing with apparatus is advocated, a procedure which is considered unwise in most American orthopaedic clinics. The indications and technique of tendon transplantations and arthrodeses are covered more adequately. Every operative procedure is considered, not as a local therapy, but in the light of the optimum balance of the body as a whole.

A Practical Guide to Massage. C. Irene Carpenter. With introduction by David Katz, Ph.D. Baltimore, William Wood and Company, 1937. $2.00.

The author has in simple, non-medical language and in a conversational manner set down her method of approach to the application of massage as a therapeutic agent, mentioning also its allied modalities, active and passive movements, and some forms of electrical stimuli.

Part I is devoted to an elementary description of the anatomy and of the physiological and biological functions of the living body, and their relation to massage.

Presupposing on the part of the reader a working knowledge of massage, in Part II Miss Carpenter gives only a general description of the manipulations and their effects. The section on "Touch and Observation" is by far the most clearly expressed part of the entire book. The importance of this factor is well emphasized.

Part III, "Some Medical Conditions for which Massage and the Allied Treatments are Prescribed", is arranged, not according to pathology, but according to the views of the author as to similarity of treatment. The brief and generalized consideration both of pathology and of prescription makes the text vague and of questionable value. Far more skill and more knowledge are required in treating the various conditions than is suggested in the text—and in this the danger lies.

The book is not adequate for those who practise massage as a mechanical procedure only, and to the well-trained physiotherapist it offers little that is new.

Orthopädische Apparate und Bandagen. Aus Klinik und Werkstatt. (Orthopaedic Apparatus and Supports.) Prof. Dr. Georg Hohmann. 2 Aufl. Stuttgart, Ferdinand Enke, 1938. 6.80 marks.

In this monograph Prof. Hohmann, director of the Orthopaedic Clinic of the University at Frankfort, a.M., attempts a description of the various orthopaedic devices, used in the clinic and at work, for different disabilities of the spine and extremities. The apparatus for the most part will find its counterpart in similar types used in American clinics.

There is much that is commendable in this book, particularly the discussion on indications for the use of the various splints which are described, with advice for their continued adjustment so that they may function efficiently. However, one is left with the feeling that each part is considered mechanically as a unit, without due consideration of it as a portion of a dynamic whole, in the light of the kinesiology and statics of the body as a unit. From the description of deformities now rarely seen, one is made to feel that insufficient emphasis is placed upon the prevention of deformities. The illustrations are clear and well drawn. There is an excellent bibliography of pertinent German medical literature.

Algunos aspectos clinicos de las heridas por arma de fuego (Some Clinical Aspects of Gunshot Wounds). Prof. M. Bastos. Barcelona, Edit. Labor, 1936.

This book of about 150 pages and seventy-four illustrations, some of them in color, is a résumé of the practical experiences of the author in regard to war surgery. In six chapters he touches upon the general aspects of war wounds, gunshot fractures, septicaemia, bacteriology, and fundamentals of treatment. In the remainder of the book, the author considers gunshot fractures of the thigh, the leg, the foot, the arm, the forearm, and the hand. War injuries to the joints, the spine, the thorax, and the neck are also discussed.

Although small, this well-written and well-illustrated book will be helpful to every surgeon interested in war surgery.

Verhandlungen der Deutschen Orthopädischen Gesellschaft. Zweiunddreissigster Kongress. (Beilageheft der Zeitschrift für Orthopädie und ihre Grenzgebiete, LXVII.) Stuttgart, Ferdinand Enke, 1938. 26 marks.

Under the editorial guidance of Prof. Hohmann, this year's *Verhandlungen* records the Thirty-Second Congress of the German Orthopaedic Society, held in Rostock on

August 27, 28, and 29, 1937, under the leadership of Dr. Scheel. The first day was assigned to a symposium on the place of orthopaedics in the physical development of the German race particularly with regard to military service. There were discussions on examination, measurement, and exercises of the body and of the feet in particular. Papers on body development, athletic ability, and miscellaneous subjects completed the day. On the second morning there was an excellent symposium on lesions of the shoulder girdle, and in the afternoon a variety of subjects were considered. The third morning was devoted to orthopaedic technique, with an interesting discussion of foot plates.

O PROBLEMA DA LUXAÇÃO CONGENITA DO QUADRIL NO BRASIL (The Problem of Congenital Dislocation of the Hip in Brazil). Rezende Puech. São Paulo, Revista dos Tribunaes, 1937.

In the first part of this book the author carefully traces various theories regarding the etiology and pathology of congenital dislocation of the hip. He regrets that so far the necessary research on the geographical distribution of that deformity has not been made. He is inclined to believe that such research would show that congenital dislocation of the hip has followed the migratory movements of peoples in whom this malformation is atavistic; as an example he quotes numerous authentic cases in the State of São Paulo, Brazil, where many of the inhabitants are of Italian origin (a race given to congenital luxation).

The second part of the book is devoted to a discussion of treatment. After giving the history of the struggle between advocates of open reduction and those who favored the bloodless method, he concludes that the dislocation should be treated by the abduction method and that it should begin as early as possible.

He states that, in his opinion, the Paci-Lorenz method is preferable; that manipulative reduction should be gentle; that before the reformation of the acetabulum walking must be avoided; and that, when bloodless manoeuvers are difficult, they should be abandoned.

In conclusion the author states that, when manipulative reduction is unsuccessful, the operative reduction should be resorted to.

Reviewing as it does the opinions and writings of the best authorities, the work of Dr. Puech has valuable information for all who are interested in the problem of congenital luxation.

INTERNSHIPS AND RESIDENCIES. Report by the New York Committee on the Study of Hospital Internships and Residencies. New York, The Commonwealth Fund, 1938.

This report includes a thorough, comprehensive study of internships and residencies in New York City by a special committee under the leadership of the late Dr. John Wyckoff. The study includes a survey of all the resources for internships and residencies in New York City, including the teaching hospitals, affiliated hospitals and non-teaching hospitals, types of residencies, fellowships, etc. Interns and residents were interviewed as were directors of hospitals, chiefs of staffs, and practitioners after they had received their training. Perhaps one can best summarize this report by saying that it shows that the average internship leaves much to be desired in the way of instruction, type of service, attention to the interns' wants and health, and sufficient time for study. The criticism of those who have practised after having had internships is that not enough attention was paid to them. They felt that they had too much major surgery, not enough Out-Patient work, not enough instruction in diagnosis; that not enough attention was paid to taking care of the common ills of life; and that too much time was devoted to the big problems as seen in the hospital wards. The residents seem to receive more in the special lines to which they devote themselves than do the interns who go through the rotating services.

It would seem that as a result of this report, it is the duty of somebody to see that the graduate instruction which interns and residents receive be better planned, and that some form of teaching must go hand in hand with the apprenticeships which the interns and residents serve. The hospital thinks it is the duty of the medical school to teach the interns and residents and the medical school thinks it is the duty of the hospital.

There is a curious inertia among many medical schools in this country today. The student receives his foundation in the medical school and is then thrown out to build his own "house" with all sorts of guides and not many plans. If there is one thing which this report shows, it is that the "doctor's house" must be completed by some form of well-organized teaching. After that he must keep his "house" in repair by frequent appearances for post-graduate instruction.

There are many illuminating factors in the book and it is recommended for the reading of all those who are interested in medical teaching and hospital management.

EIGHTH INTERNATIONAL CONGRESS OF MILITARY MEDICINE AND PHARMACY AND MEETINGS OF THE PERMANENT COMMITTEE. Report of Captain William Seaman Bainbridge, M.C.-F., U.S.N.R., Ret. Washington, United States Government Printing Office, 1937. $1.00.

This book is a report of the Eighth International Congress of Military Medicine and Pharmacy held in Brussels, Belgium, June 27 to July 3, 1935. This Congress, which was instituted by the late King Albert of Belgium in 1921, has gathered representatives of many nations to confer on subjects vital to health and to the prevention and management of disease, as well as the different problems incident to war. The report contains material and discussions presented during the Congress by the delegates from various countries. The book will be of value to medical military officers who are engaged in this work.

OSTEOCONDROSIS DE CRECIMIENTO (OSTEOCONDRITIS). Dr. Augustin A. Salvati. Buenos Aires, El Ateneo, 1937.

Considering that the different types of osteochondritis (Osgood-Schlatter disease, Legg-Perthes disease, Larsen-Johansson disease, etc.) are due to aseptic necrosis of the bones, Dr. Salvati thinks that the correct name for this group of diseases would be "osteochondrosis",—for example, "osteochondrosis juvenilis of the hip joint", "osteochondrosis of the patella", etc.

His interpretation of the genesis of osteochondrosis is: "a traumatic factor, acting either alone or associated with predisposing factors of diverse cause, which produces vascular ischaemias in epiphyseal areas, resulting in foci of aseptic necrosis".

For the treatment of osteochondrosis of the hip joint, he has used in six cases, with good results, a bone graft taken from the tibia and implanted through the neck of the femur. This method results in a better blood supply to the head of the femur.

A short historical review and a clinical description of the different types of osteochondrosis, based upon thirty-nine cases, are also included.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

Archivos de la Sociedad de Cirujanos de Hospital (Santiago de Chile), VII, Nos. 8 and 9, 1937.

Bollettino e Atti della Reale Accademia Medica di Roma, LXIII, Fasc. 5–8, 1937.

The Child (Washington, D. C.), II, Nos. 8–11; Supplement 3 to Nos. 9–10; 1938.

Cleveland Clinic Quarterly, V, No. 2, 1938.

Current Medicine (Los Angeles), V, Nos. 5 and 6, 1938.

Gaceta Peruana de Cirugía y Medicina (Lima), I, No. 2, 1938.

Medicine Today (Brooklyn, N. Y.), I, No. 3, 1938.

Radiography and Clinical Photography (Rochester, N. Y.), XIV, Nos. 2 and 3, 1938.

Revista de Cirugía del Hospital de Juárez (Mexico City), IX, No. 1, 1938.

Roche Review (Nutley, N. J.), II, Nos. 7, 8, and 9, 1938.

The Rotarian (Chicago), LII, No. 4, 1938.

University of Pennsylvania Bulletin. Graduate School of Medicine, Announcement for Session 1938–1939. Philadelphia, 1938.

Fractures and Dislocations. Volumes I and II. Philip Lewin, B.S., M.D. Edited by Morris Fishbein, M.D. New York, National Medical Book Co., Inc., 1937.

Über Olekranonfrakturen und deren Behandlungsresultate (Fractures of the Olecranon and the Results Following Treatment). E. Laukka. *Acta Chirurgica Scandinavica*, LXXIX, 93, 1936.

Of 103 patients with fracture of the olecranon, whose cases were studied, fifty-six returned for follow-up examination. Statistical data are recorded and the associated fractures are tabulated. Simple immobilization sufficed in the subaponeurotic type with separation of three millimeters. Bony union was obtained in 100 per cent., and good results in 90 per cent. When separation or comminution was present, semicerclage with wire was usually employed. With internal fixation, good results were obtained in 66 per cent.; a complete range of motion, in only 21 per cent.; and pseudarthrosis, in 18 per cent. Traumatic arthritis was present in 36 per cent. of the operated cases, but the functional result was good in half of these cases.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Intraärticular Malleolar Fractures. A Survey. ThoreWalheim. *Acta Chirurgica Scandinavica*, LXXIX, 166, 1936.

In 127 cases of intra-articular malleolar fractures, open reduction was performed in thirty-seven. Follow-up examinations showed the results to be better in the operated cases. Four and seven-tenths per cent. of the entire series of patients received disability compensation and 10 per cent. showed roentgenographic evidence of traumatic arthritis. The results in cases of fracture of the roof of the mortise were poorer than in those involving only the lateral supporting surfaces. End-result statistics are tabulated. These are compared with the results in 245 similar conservatively treated fractures from the Government Insurance Bureau in which the disability was more than twice as great. The writer suggests an extension of the indications for open operation. Skeletal traction was not used.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Über die Technik bei Inforatio Colli et Capitis Femoris ("Forage" nach Graber-Duvernay) [The Technique of Drilling the Head and Neck of the Femur]. Aage Berntsen. *Acta Chirurgica Scandinavica*, LXXX, 82, 1937.

In from 60 to 100 per cent. of the published cases of osteo-arthrosis of the hip joint in which the neck of the femur has been drilled, the pain has diminished. The procedure is indicated when there is unilateral involvement without excessive subcutaneous fat. The favorable outcome is attributed variously to changes in circulation; introduction of fresh granulation tissue and bone dust into the drill holes, thus contributing to new ossification; and alteration of the articular cartilage by the circulatory changes.

The technique is outlined for placing and withdrawing a screw with the aid of two sets of lead markers, a lead rule, and a level. The writer has treated twenty-nine patients in this manner, with diminution of the pain in all but two cases. In five cases there was recurrence of the pain.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

A Comparative Study of the Treatment of Oblique Fractures of the Shaft of the Tibia by Osteosynthesis, Osteotraction or only Reduction and Plaster. Oskar Lindén. *Acta Chirurgica Scandinavica*, LXXX, 365, 1938.

Follow-up examinations of some 250 cases of fracture of the shaft of the tibia furnish the material for 151 case summaries and the detailed tabulation of etiological data and end results. Errors from economic differences were minimal because all patients were from the same hospital and each method of treatment was used without selection of cases for a well-defined period of time (1908 to 1932). Internal fixation was by means of a screw in all but one case. Skeletal traction was used for from three to six weeks and then removed for the application of plaster in all but two cases in which the cast was applied immediately. Throughout the period simple immobilization in plaster with or without reduction was employed whenever possible, but only the cases since 1919 are included in this report.

The writer found that skeletal traction frequently allowed shortening and angulation. He characterized this form of treatment as troublesome and uncomfortable. Open reduction and fixation with a screw gave better end results and shorter healing periods. When done immediately, open reduction and internal fixation showed better results in oblique fractures than did closed reduction and the application of a cast, in spite of the fact that the latter form of treatment was used chiefly in the simpler cases. Among the cases operated upon, however, there was one case of tetanus, and one thigh amputation was necessary because of infection. It is stipulated that open reductions should be done only by experienced surgeons and under reliable aseptic conditions.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

On Infantile Coxitis and Its Sequelae. Soren Chr. Iversen. *Acta Orthopaedica Scandinavica*, VIII, 231, 1937.

Follow-up examinations of twenty-nine cases of infantile coxitis furnish the material for a critical review of the subject. The cases are arranged in three groups according to acute symptoms, and again into four according to late pathological changes. Early drainage and fixation are advocated in the acute stage, and a subtrochanteric osteotomy for the correction of the frequent late deformity. Case summaries are appended.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Late Results of Operation for Congenital Torticollis. Jens Foged. *Acta Orthopaedica Scandinavica*, VIII, 293, 1937.

Of 131 patients operated upon for congenital torticollis, 117 were subjected to follow-up examinations. A statistical review of these cases is furnished. Simple open myotomy at the distal end of the muscle was done in most cases and was followed by the application of a Schanz cotton collar. The internal jugular vein was injured twice. There were mild infections in three cases. End results were good in 86 per cent., fair in 11 per cent., and poor in 3 per cent. Other results are quoted from the literature.—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

Nachuntersuchungen von Patienten, behandelt wegen Spondylitis tuberculosa auf dem Seehospital bei Stavern 1911–1929 (End-Result Study of Patients Treated for Tuberculous Spondylitis at the Sea Hospital at Stavern, 1911–1929). Agnar Grevle. *Acta Orthopaedica Scandinavica*, VIII, 305, 1937.

Two hundred and thirty-seven cases of tuberculosis of the spine, in which 163 of the patients were under and seventy-four were over fifteen years of age, were investigated by questionnaire (10 per cent. by examination) in the interest of the statistical study which is submitted in detail. Spine fusion was performed only twice. Casts were applied in sixty-seven cases. Corsets were used in seventy-nine of the earlier cases,

and twenty-one of the patients continued to get worse. In sixty-seven of the later cases plaster beds and no corsets were used, and seven of the patients became worse. The figures are not comparable in evaluating the methods of support, however. In all, about half of the patients remained well. Thirty-nine died while under treatment (five from non-tuberculous causes); forty-seven died after leaving the hospital (three from non-tuberculous causes).—*W. P. Blount, M.D., Milwaukee, Wisconsin.*

FURTHER EXPERIENCE IN THE DIAGNOSIS OF HYPERPARATHYROIDISM, INCLUDING A DISCUSSION OF CASES WITH A MINIMAL DEGREE OF HYPERPARATHYROIDISM. Fuller Albright, Hirsh W. Sulkowitch, and Esther Bloomberg. *American Journal of Medical Sciences*, CXCIII, 800, 1937.

This report is based on thirty-five cases of hyperparathyroidism, proved by operation, studied at the Massachusetts General Hospital over a ten-year period. The authors bring out the fact that cases are sent to them which are not being recognized at other clinics. These cases include: (1) those with no demonstrable bone disease (twelve cases); and (2) those with a very moderate degree of hyperparathyroidism (eight cases). The presence or absence of bone disease is not an indication of the degree of hyperparathyroidism,—some of the severe cases did not have it and some of the mild ones did have it. In patients with bone disease and high serum-phosphatase levels, as a rule, postoperative hypocalcaemia develops; it seldom occurs in other cases.—*M. Mendelsohn, M.D., Iowa City, Iowa.*

THE TREATMENT OF ACUTE INFECTIOUS ARTHRITIS OF UNDETERMINED ORIGIN WITH ARTIFICIAL FEVER. Robert M. Stecher and Walter M. Solomon. *American Journal of Medical Sciences*, CXCIV, 485, 1937.

Acute non-specific infectious arthritis is a relatively common syndrome which has received scant attention in the literature and may be regarded as an acute form of atrophic, rheumatoid, or chronic infectious arthritis.

Of twenty patients, ranging in age from fourteen to fifty-one years, treated with artificial-fever therapy, twelve (60 per cent.) received prompt relief and apparent cure, while eight (40 per cent.) were partially relieved. The course of the disease was favorably modified in every case. These results compare favorably with those observed in the treatment of acute gonorrhoeal arthritis with artificial fever.

Treatment consisted in induced fever (about 105 degrees Fahrenheit) by means of the Kettering hypertherm, maintained usually for four or five hours. The patients who recovered completely received this treatment for from two to twenty-five hours, averaging seven and three-tenths hours.

Increased circulation, with an increase in phagocytosis, occurs, but the complete mechanism which produces benefit is not fully known.

Herpes labialis has been found to occur as a complication of this form of therapy in one-third of the cases after the first treatment only.—*M. Mendelsohn, M.D., Iowa City, Iowa.*

SOME THEORETICAL CONSIDERATIONS IN THE CONSTRUCTION OF ACTIVE SCOLIOSIS BRACES. Josef Wolf. *American Journal of Surgery*, XXXIX, 557, March 1938.

The author reviews the literature in regard to the types of so-called active scoliosis braces, referring especially to apparatus worn during the day, with attempt to correct the deformity by mechanical means. He divides the components of the curve into: (1) curvature of the spine itself; (2) overhang on one side of the pelvis; (3) torsion and hump formation; (4) diminution of the height of the body.

The difficulty of bringing mechanical forces to play upon the spine itself is reviewed. This can only be done effectively through the ribs, with the correcting force applied below

the apex of the curve and the line of pressure being directed obliquely in conformity with the position of the rib.

A design is suggested for the axillary crutch which would avoid undue pressure upon the anterior and posterior muscles of the chest. The author stresses the importance of a well-fitting rigid pelvic support, upon which the levering mechanism is dependent in the correction of the elements of the curve. He also emphasizes the futility of lifting the shoulder girdle in attempting to correct the thoracic deformity.—*Custis Lee Hall, M.D., Washington, D. C.*

AMBULATORY METHOD OF TREATING FEMORAL SHAFT FRACTURES, UTILIZING FRACTURE TABLE FOR REDUCTION. Roger Anderson. *American Journal of Surgery*, XXXIX, 538, March 1938.

This article embodies the continuation of the author's well-known method of pin fixation and reduction of fractures of the femur, using two pins above and two below. He stresses the importance of spiral fractures causing difficulty due to locking of the fragments, and that overtraction is often necessary to obtain proper reduction.

A series of cases is reported which shows excellent reduction of subtrochanteric and supracondylar fractures. The advantage claimed by the method is better control of the fragments and more rapid and secure reduction which, when properly done can be maintained by the incorporation of the upper and lower pins in a well-fitting plaster cast. Two pins are used below to prevent lateral slipping of the lower fragment. The method is claimed to give much more rapid rehabilitation, less hospitalization, freedom of hip and knee movements, minimum of aftercare and thorough maintenance of fragments in correct position.—*Custis Lee Hall, M.D., Washington, D. C.*

ROENTGENOGRAPHIC FEATURES OF TUBERCULOSIS IN BONES AND JOINTS. Charles G. Sutherland and Ercell A. Addington. *American Review of Tuberculosis*, XXXVII, 31, Jan. 1938.

Tuberculosis of bone is a metastatic process. An embolism of bacilli is carried to the region by the blood stream and deposited either in synovia or in marrow. The outstanding roentgenographic characteristic is the translucency of the bone shadow without evidence of proliferation of bone. Regional bone atrophy and loss of the bony articular surface in non-contacting areas, with preservation of the bony articular cortex in contacting areas, occur early. Sequestra are rare. These changes appear as rarefaction with little evidence of reaction of tissues and clouding of the joint.—*M. Rosenbaum, M.D., Iowa City, Iowa.*

FRACTURAS SUPRACONDILEAS INFANTILES (Supracondylar Fractures in Children). F. Jimeno Vidal. *Anales del Servicio de Traumatología, Cirugía Ortopédica y Accidentes del Trabajo del Hospital Provincial de Valencia*, Febrero 1936.

The great osteogenetic capacity of the infantile periosteum and its tendency to bone proliferation when it is irritated are the chief reasons for the use of gentle manipulations, the postponement of any kind of surgical operation, and the establishment of after-treatment on the lines of uninterrupted rest until bony union takes place. The author warns against removing the splint every two days in order to see "how things are going on", moving the joint, or employing any form of massage.

The fracture is reduced under a local anaesthetic (20 cubic centimeters of a 2-percent. novocain solution). The patient is placed on a table, and the surgeon exerts traction, pulling the forearm flexed at a right angle. Countertraction through a sling, or obtained by placing the surgeon's knee on the patient's axilla, is effective. This causes the shortening to disappear. Digital pressure reduces the forward position of the proximal fragment. The forearm should be held in forced pronation to counteract the varus position and to prevent radial palsy. Fixation is by means of a non-padded plaster-of-Paris splint.—*Francisco P. Dueño, M.D., Madrid, Spain.*

UN NUEVO MÉTODO DE TRATAMIENTO DE LAS FRACTURAS DEL CUELLO DEL FÉMUR (A New Method for the Treatment of Fractures of the Neck of the Femur). E. T. López-Trigo. *Anales del Servicio de Traumatología, Cirugía Ortopédica y Accidentes del Trabajo del Hospital Provincial de Valencia,* Mayo 1936.

Since the usual method of treating intertrochanteric fractures—keeping the patient in bed for two or three months—is not safe in treating elderly patients, the author presents a method which reduces the time in bed without impairing the reduction and consolidation of the fracture.

After taking two roentgenograms and putting the leg in a Braun splint, the author inserts a Kirschner wire through the femoral condyles and attaches a fifteen-kilogram weight. Traction is maintained until the coxa-vara position is changed into a position of forced coxa valga. When the changed position is apparent roentgenographically, without removing the weight, the author applies a plaster-of-Paris spica. The wire is then removed, and a zinc-glue bandage applied to the leg and foot enables the patient to walk. This bandage is worn for three months. Sixty-three patients have been treated by this method with satisfactory results.—*Francisco P. Dueño, M.D., Madrid, Spain.*

FRACTURAS ABIERTAS DIAFISARIAS (Compound Fractures of the Shaft). E. T. López-Trigo. *Anales del Servicio de Traumatología, Cirugía Ortopédica y Accidentes del Trabajo del Hospital Provincial de Valencia,* Julio–Diciembre 1936.

During the past five years the author has had under his care 448 cases of compound fracture of the shaft in civilians. Of these, 398 were operated on within five hours after injury; in the other fifty cases the operation was not performed until this time had elapsed. In the first group, there were only ten cases of severe infection of the gangrenous type and no deaths; in the second group, gangrenous infection resulted in sixteen cases; amputation, in six; and death, in four.

Over the same period the author also treated 142 cases of gun-shot fractures of the shaft. In this series five gangrenous infections and eight severe non-gangrenous infections developed, and there were three amputations and two deaths.

The author recommends primary suture, after mechanical cleansing of the wound, during the first five hours following the injury; fixation of the fragments in plaster or the insertion of a Kirschner wire. The successful outcome of these cases depends on perfect immobilization. When primary suture is impossible, the author recommends vaselin-gauze packing and plaster-of-Paris cast.—*Francisco P. Dueño, M.D., Madrid, Spain.*

GIANT CELL TUMOR OF THE CERVICAL SPINE. DeForest P. Willard and Jesse Thompson Nicholson. *Annals of Surgery,* CVII, 298, Feb. 1938.

Giant-cell tumor of the cervical spine is a comparatively rare lesion. The authors estimate that the lesion occurs in the vertebrae in about 8 per cent. of the cases. The cervical vertebrae are reported involved in seven instances.

A decided majority of all giant-cell tumors occur in individuals over twenty years of age, but the majority of vertebral lesions are found in individuals under twenty years of age.

Giant-cell tumor is classified as non-malignant, but Coley and Meyerding reported the cases of patients who died of metastases. Geschickter and Copeland recognize a "malignant variant which is the result and not the cause of recurrence". They also claim that the "malignant variant" structure is primary and, if recurrence results, metastasis is apt to follow. One would infer from this that inadequate removal is responsible for secondary changes in the tumor.

The authors conclude that the treatment of choice is curettement; if this fails resection or amputation must be performed.

The case reported by the authors was that of a white female, aged nine. When the

child was first examined, it was believed that there was a forward dislocation of the right inferior facet of the third cervical vertebra. She was treated in hyperextension for two weeks without any results and then a Walton manipulation was done, followed by application of a plaster cast to the head and the torso. Several weeks later when the cast was removed, roentgenographic examination revealed the presence of a rounded cystic tumor, projecting posteriorly from the fourth cervical vertebra. The tumor was completely removed by laminectomy. Pathologically, it resembled the spindle-cell variant of giant-cell tumor recognized by Geschickter and Copeland. One year after removal the patient was free from symptoms and roentgenographic examination did not show any recurrence.—*O. B. Bolibaugh, M.D., San Francisco, California.*

TREATMENT OF FRACTURES OF THE SHAFT OF THE FEMUR. AN ANALYSIS OF ONE HUNDRED AND TWENTY CASES. Robert H. Kennedy. *Annals of Surgery*, CVII, 419, Mar. 1938.

The author analyzed 120 consecutive cases of recent fractures of the shaft of the femur treated by the Staff of the Beekman Street Hospital from January 1924 to March 1932. These patients were treated by some ten different surgeons, but each case had the advantage of General Staff discussions of the details of the treatment.

Patients were classified according to the location of the fracture and according to age.

There were seventeen early deaths in the series, including one patient who died after amputation was performed. There were two other patients requiring amputations. This leaves one hundred and one patients for detailed analysis of treatment. Fourteen of the early deaths occurred in patients with severe multiple injuries.

Forty-eight of the patients analyzed were under sixteen years of age. Forty-seven had fractures resulting from automobile accidents. There were but four compound fractures and twenty comminuted fractures in the series.

The primary hospital treatment in forty-three cases was adhesive-plaster traction with suspension in a Thomas splint; skeletal traction was used in thirty-five cases; overhead adhesive-plaster traction in eleven cases; reduction and application of a plaster spica in eleven cases, and open reduction in one case.

The final treatment, except where complications occurred, was skeletal traction in forty-three cases; adhesive-plaster traction with suspension in a Thomas splint in thirty-one cases; reduction and application of a plaster spica in twelve cases; overhead adhesive-plaster traction in eleven cases, and open reduction in four cases.

The initial treatment was unsatisfactory in fourteen cases of adhesive-plaster traction with suspension and in two cases treated by reduction and application of plaster spica.

Traction methods were employed in treating 87 per cent. of these patients. The author prefers the Kirschner wire to tongs and Steinmann pins which were used in the earlier cases.

There were four open reductions, all in children. In three cases there were simple fractures and one was compound. In the compound-fracture case infection developed, followed by osteomyelitis, but solid union occurred.

Three patients required late open reductions for complications. Four patients sustained refractures.

In eighty-four patients solid bony union was known to have developed and in one non-union developed.

The author concludes that by traction methods bony union with relatively little shortening and good functional results may be obtained in a high percentage of cases. He does not feel that the results obtained in this series were good enough. Overhead adhesive traction was satisfactory in children under five years of age. Skin traction was unsatisfactory in children over five years of age from the point of view of recovering original length. Skeletal traction in adults gave too high an incidence of infection. He condemns closed reduction and application of a plaster spica.

In March 1932 the surgeons changed to Russell traction in all of these groups. They are still not satisfied with their results and believe that they should perform more open reductions with internal fixation especially in transverse fractures of the middle and lower thirds of the femur.

Skeletal traction has been a marked improvement over reduction and application of a plaster spica or adhesive-plaster traction with suspension in a Thomas splint. No single method is applicable to all cases and one should be ready to use each type of treatment according to the individual indications.—*O. B. Bolibaugh, M.D., San Francisco, California.*

INJURIES ABOUT THE SHOULDER JOINT IN CHILDREN, EXCLUSIVE OF FRACTURES OF THE CLAVICLE. John E. Sullivan. *Annals of Surgery*, CVII, 594, Apr. 1938.

The author made a study of the records of sixty-one children under twelve years of age, with injuries about the shoulder joint, exclusive of fractures of the clavicle, who had been admitted to the Children's Surgical Service of Bellevue Hospital during the past ten years.

Fifty-five of these patients had fractures of the upper end of the humerus, four had fractures of the scapula, one had a subluxation of the head of the humerus, and one had an acromioclavicular separation. There were no instances of separation of the upper humeral epiphysis or of apparent injury to this epiphysis.

Most of the fractures were produced by a fall, and the author describes in detail the mechanics of the injury.

Various methods of treatment did not give anatomical reductions but functional results were excellent and in many instances complete anatomical readjustment occurred in a few months.

There were three pathological fractures of the upper end of the humerus in the series. Fractures occurred more often in the left than in the right humerus. There were three cases of fracture of the body of the scapula which were all caused by severe trauma.

The methods of treatment used were manipulations under anaesthesia or traction.—*O. B. Bolibaugh, M.D., San Francisco, California.*

ÄTIOLOGIE- UND SCHMERZPROBLEME BEI DER GENUINEN ARTHROSIS DEFORMANS. (KLINISCHE UND TIEREXPERIMENTELLE UNTERSUCHUNGEN ÜBER DIE PHYSIOPATHOLOGIE DER GELENKKAPSEL.) [Etiology and Production of Pain in True Arthritis Deformans.] H. R. Paas. *Archiv für klinische Chirurgie*, CLXXXVIII, 1, 1937.

In a consideration of the etiology and pathology of idiopathic arthritis deformans—also known as degenerative or hypertrophic arthritis—one is impressed by the concerted teaching of the past that the primary pathological changes are in the articular cartilage. The capsular changes and their importance are entirely overlooked.

The author presents convincing evidence that the synovial membrane and capsule are the seat of very early pathological changes as a result of a deficient vascularization. This poor circulation of the capsular apparatus is responsible for an altered permeability of the synovial membrane and a disturbed production of the synovial fluid. The author presents experimental data which show that the absorption time of contrast fluids injected in joints was regularly increased with advancing age of the animals. With the decreased permeability is associated an increased intra-articular pressure. The decreased permeability and increased intra-articular tension are due to a decreased elasticity of the synovial membrane and the connective tissue therein. The capsule shrinks, and the absorbing joint surface becomes greatly reduced.

Subjective complaints vary directly with these pathological phenomena. The latter account for the frequent presence of severe subjective symptoms in a joint which shows very little or no objective deformity in the roentgenogram.

In the treatment of these joints, therapy must be directed to increase the circulation of the involved tissues. The author recommends intra-articular injections of substances

that produce a prolonged hyperaemia in the periarticular tissues, resulting in an increased production of synovial fluid, stretching of the capsule, and diminution of pain. For this purpose, the author employs a high molecular fatty acid ester called "immetal" and obtains very gratifying results.—*Harold Unger, M.D., Iowa City, Iowa.*

PATHOLOGISCHE ANATOMIE DER MENISCUSSCHÄDEN (Pathology of Meniscus Lesions). W. Ceelen. *Archiv für Orthopädische und Unfall-Chirurgie*, XXXVII, 334, 1937.

The author studied two series of semilunar cartilages: (1) 200 post-mortem specimens; (2) 270 surgical specimens.

In the first group he found degenerative processes in 40 per cent. This susceptibility to degeneration is explained as being due to poor blood supply. Blood vessels enter the cartilage at its marginal aspect and at the cornua, supplying about one-third of the width of the cartilage. The remaining two-thirds has neither blood nor lymph vessels. Nutrition is supposed to take place from the synovial fluid by diffusion. The author found hyaline thrombosis of meniscus vessels in a case of endocarditis lenta and septicaemia, and a purulent meniscitis with total breakdown of the cartilage in another case of pyaemia. In cases of chronic nephritis and arteriosclerosis he found exhaustive degeneration with spontaneous liberation of menisci.

In the second group the author found that healing of small tears takes place by scar formation and that the larger tears heal by organization of the lacerated edges or by a partial regeneration if the capsule connection is intact.—*D. H. Bruns, M.D., Iowa City, Iowa.*

OBJEKTIVE UNTERSUCHUNGSMETHODE ZUR FESTSTELLUNG DER BEWEGUNGSMÖGLICHKEIT DER WIRBELSÄULE (Objective Methods of Examination to Demonstrate Vertebral Mobility). Rostock. *Archiv für Orthopädische und Unfall-Chirurgie*, XXXVIII, 263, 1937.

The author reenforces visual examination of spinal mobility by examination of lateral roentgenograms of the thoracolumbar and lumbosacral spine in maximal flexion and maximal extension. If the sacra are superimposed, the levels at which abnormal mobility is present may be analyzed. In controversial cases, the method has proved of value.—*J. E. Milgram, M.D., New York, N. Y.*

DIE BEWEGUNGSBEHANDLUNG DER KNIEGELENKEITERUNG NACH WILLEMS UND IHRE ERFOLGE (The Willems Treatment of Knee-Joint Suppuration by Active Motion and Its Results). Hohlweg. *Archiv für Orthopädische und Unfall-Chirurgie*, XXXVIII, 268, 1937.

The author advocates the use of the Willems method of active motion after parapatellar incisions have been used to drain the knee joint. The incisions curve back somewhat, are adequate to expose the recesses of the joint, and avoid division of the lateral ligaments or essential extensor apparatus of the knee. The synovia is stitched to the skin. A wire through the os calcis and suspension of the limb make it easier to obtain motion early. The author finds the pain has not been as severe as reported. He resorts to x-ray radiation of the knee and transfusions as useful adjuncts.

Since January 1935, nine cases have been adequately followed, and good mobility of the knees has resulted in seven.—*J. E. Milgram, M.D., New York, N. Y.*

SHORT WAVE DIATHERMY IN SUBDELTOID BURSITIS. Louis Feldman. *Archives of Physical Therapy*, XVIII, 411, 1937.

The author has drawn his conclusions from 100 cases of subdeltoid bursitis in which some degree of calcification was present. The technique was as follows: twenty-four-

meter short-wave diathermy was used for treatments composed of exposures to from 700 to 1,500 milliamperes for twenty minutes every day for one week, then every two days for one week, and then biweekly for from two to four weeks or until symptoms disappeared. The results show relief of pain by three to six treatments and return of function by ten to twelve treatments. The author recommends this therapy in all cases of subdeltoid bursitis. The only contra-indication is a purulent bursitis.—*J. B. Davis, M.D., Iowa City, Iowa.*

SPINE FUSION IN TUBERCULOUS SPONDYLITIS. A. Strasser. *Archivio di Medicina e Chirurgia*, Febbraio 1937.

The author feels that the conservative views of Calot and Galeazzi in dealing with tuberculosis of the spine have lost a great deal of weight in view of the many splendid results obtained by operation. He believes that surgery is not indicated in tuberculosis of the cervical spine. He also points out that fusion between the bodies of the vertebrae and the laminae does not occur before the sixth year, and he does not operate on children under six years of age. Furthermore, tuberculosis of the spine in children has a better outlook without surgery than in adults, and, as the economic factor is not so important, the author usually prefers to wait until the patients have attained the age of sixteen before he does fusion operations. However, he favors the operative treatment in adults and feels that the possibility of giving those patients many years of useful existence is reason for attempting an operation which is not dangerous.

Of sixty-eight patients followed over one year, the author reports cure in 81 per cent., improvement in 13 per cent., no improvement in 4.5 per cent., and death in 1.5 per cent.

The author favors the use of local anaesthesia exclusively, and he operates through a window in a body jacket. He tries to get his patients on their feet in thirty days. One-half of his patients were ambulatory at the end of this period, and no ill effects were noted.—*A. W. Ciani, M.D., Iowa City, Iowa.*

SULLE FRATTURE ISOLATE CONDILOIDEE E DIACONDILOIDEE DELL'ESTREMO INFERIORE DELL'OMERO E LORO ESITI (Isolated Condylar and Diacondylar Fractures of the Lower End of the Humerus). Luigi Racugno. *Archivio di Ortopedia*, LIII, 255, 1937.

Fracture of the external condyle of the humerus was found to be the most frequent fracture of the lower end of the humerus, occurring in 38 per cent. of fifty cases. Isolated fracture of the internal condyle was present in two cases, fracture of the eminentia capitata and diacondylar fractures were represented by one case each. The mechanism, clinical and roentgenographic symptomatology, and treatment are discussed.

In eight cases with incomplete fracture or complete fracture with little displacement, good consolidation with complete use of the arm was obtained without any growth disturbance even several years after trauma. In only one case did cubitus valgus occur. In four cases of fracture of the outer condyle with displacement and rotation of the fragment around its own axis, open reduction with fixation of the fragment was performed to prevent pseudarthrosis, cubitus valgus, and limitation of motion. The late results were excellent in both anatomical and functional respects. Surgical removal of the external condyle was performed in five old cases in which there was malunion. The functional result was excellent two to three years after the operation, but there was a moderate degree of cubitus valgus. The author feels that fracture of the eminentia capitata is best treated by closed reduction. One case of isolated fracture of the inner condyle without displacement was treated with simple immobilization in a bandage of plaster-of-Paris for three weeks; the result was good. In another case with more displacement an open operation was performed and the fragment was replaced and screwed on; the result was also satisfactory.—*Ernst Freund, M.D., Los Angeles, California.*

NUOVI CRITERI DIRETTIVI DELLE OSTEOTOMIE SOTTOTROCANTERICHE NELLE LUSSAZIONI INVETERATE DELL'ANCA (New Indications for Subtrochanteric Osteotomy in Congenital Dislocation of the Hip Joint). A. Albanese. *Archivio di Ortopedia*, LIII, 347, 1937.

After a historical review of the development of subtrochanteric osteotomy from the corrective procedure of Kirmisson to the bifurcation operation of Lorenz, the author discusses critically all the advantages and disadvantages of the different procedures and especially the importance of the mechanical support of the pelvis by the proximal fragment. Since 1933, Albanese has used a Z-shaped subtrochanteric osteotomy which presents several advantages,—namely, it keeps the fragments in better contact; the proximal fragment is placed in adduction, thus tightening the abductor muscles; it further permits lengthening of the extremity; there is no danger of pseudarthrosis or ankylosis of the hip joint. The author reports several cases in which the procedure has been carried out with success.—*Ernst Freund, M.D., Los Angeles, California.*

LA PERIARTRITE CALCAREA DEL GOMITO (Periarticular Calcification of the Elbow). Aldo Fiorentini. *Archivio di Ortopedia*, LIII, 385, 1937.

The author has observed four cases of an elbow lesion which clinically has great resemblance to tennis elbow, but roentgenologically and histologically the cases belong to the group of periarticular calcifications. In none of the cases was there a history of trauma. In only one case was surgical intervention necessary. In the other three cases roentgenotherapy was instituted,—two patients were completely cured and the calcification disappeared; the third patient improved under roentgenotherapy, but symptoms recurred. The specimen removed from the patient who was treated surgically showed that the calcification was within the tendon tissue of the common extensor muscle.—*Ernst Freund, M.D., Los Angeles, California.*

SUL TRATTAMENTO DELLE FRATTURE MAL CONSOLIDATE, DELL'ESTREMO INFERIORE DELL OMERO (On the Treatment of Malunion of the Lower End of the Humerus). A. Albanese. *Archivio di Ortopedia*, LIII, 417, 1937.

In the treatment of malunion of the lower end of the humerus several important factors must be taken into consideration, which the author lists as follows:

1. Joint stiffness, which is considered mainly as a defense mechanism to prevent pain. In such cases physical therapy should not be forced. The joint should be immobilized in the early stages; later, motion should alternate with rest periods.

2. Post-traumatic para-articular ossification. The best prophylaxis for traumatic myositis ossificans is early and accurate reduction followed by immobilization. If, despite every precaution, there is the imminent danger of para-articular ossification, x-ray therapy should be tried. It gives good results in the early and recurring stages of ossification. More extensive ossifications with bone-block formation require surgery.

3. Limitation of joint motion by displacement of the fragments in the sagittal plane. In Kocher's extension fractures, the distal end of the shaft lies in front of the epiphysis and interferes with flexion. Treatment consists in surgical removal of the prominent portion of the diaphysis. Albanese has operated in a few cases, doing a resection of the lower end of the diaphysis and a curved osteotomy to prevent too extensive areas of roughened bone. In flexion fractures with displacement of the epiphysis forward, a hinge osteotomy is performed in the sagittal plane. In more severe cases, a wedge osteotomy has to be resorted to, with a posterior base, through a lateral or posterior incision.

4. Displacements in the frontal plane. In cases of valgus deformity of the elbow, reduction and fixation by periosteal stitches are advocated for fracture of the outer condyle, occasionally with temporary osteosynthesis by foreign material. Where there is varus deformity of the elbow, a hinge osteotomy in the frontal plane through a lateral or posterior incision is recommended, or a hemiwedge osteotomy with base outward.—*Ernst Freund, M.D., Los Angeles, California.*

LE COSIDDETTE "EPIFISI MARGINALI" O PUNTI COMPLEMENTARI TARDIVI D'OSSIFICAZIONE DELLE PARTI LATERALI DELL'OSSO SACRO (The so-called Marginal Epiphysis or Accessory Points of Ossification of the Lateral Portions of the Sacrum). Gioffredo Giraudi. *Archivio di Ortopedia*, LIII, 481, 1937.

The author calls attention to the accessory epiphyses of the marginal portions of the sacrum. They are known and described in the textbooks, but Giraudi believes that the textbook descriptions do not conform to the actual findings. He gives as an example the schematic picture of Testut, which shows the bony development in the sacrum and the appearance of two marginal epiphyses, one extending along the auricular surface of the sacrum and comprising the upper two segments, and the other extending over the lower part of the sacrum and comprising the remaining three segments. Giraudi found these marginal epiphyses quite frequently, but only belonging to the upper sacral segments. Occasionally the epiphysis extends, wedge-like, into the space between the first and second sacral segments. These marginal epiphyses are usually found together with a bony nucleus in the posterior superior iliac spine, one extending along the iliac crest and another from the sciatic tuberosity along the inferior margin of the ascending branch of the ischium. These epiphyses may have some practical importance because a tuberculous process may have its origin in an accessory epiphysis.—*Ernst Freund, M.D., Los Angeles, California.*

A PROPOSITO DELL'IMPIEGO DEI RAGGI ROENTGEN NEL TRATTAMENTO DELL'EPICONDILITE (Concerning the Use of X-Ray in the Treatment of Tennis Elbow). A. Mastromarino. *Archivio di Ortopedia,* LIII, 497, 1937.

The question whether x-ray or surgical treatment is preferable in cases of epicondylitis of the humerus is still under discussion. The author is very much in favor of surgery, but he does not deny that occasionally x-ray treatment is efficient and almost always frees the patient from pain. Chronic cases, however, with inflammatory and anatomical lesions of the common extensor of the fingers, should be treated surgically because x-ray treatment gives only temporary relief.—*Ernst Freund, M.D., Los Angeles, California.*

ANZEIGSTELLUNG UND TECHNIK DER LUNATUMEXSTIRPATION (Indication and Technique of Lunate Extirpation). Walter Nell. *Bruns' Beiträge zur klinischen Chirurgie,* CLXV, 619, 1937.

In general, dislocated lunate bones should be reduced if at all possible. Open reduction is possible three, four, or even six weeks after displacement. Böhler, using mechanical distraction at open operation, in one case reduced a dislocation of six months' duration. As a rule, end results are good in these reduced dislocations of the lunate.

Fractures of the lunate rarely form pseudarthroses as do fractures of the navicular, and operative excision is indicated only rarely in comminuted fractures. Long fixation may be required in fracture of the lunate.

Extirpation is reserved for cases of lunate malacia which have been treated for at least six months by rest, without success. If arthritis deformans is visible roentgenographically, it is too late (in the opinion of Polchau) to operate, since neither function nor pain will be improved.

To spare the remaining important wrist ligaments, the author advocates the palmar incision. The dorsal incision, while easier, injures many ligaments, which later results in serious carpal disturbances. It is difficult to avoid traumatizing the adjacent joint cartilages through a dorsal incision, since extensive stripping is required. A curved tenotome helps to free the bone at operation, dividing only the ligaments which insert on the lunate. A longitudinal incision, from five to six centimeters in length, is used, commencing one centimeter above the pisiform. The median nerve and finger flexors are retracted ulnaward.—*J. E. Milgram, M.D., New York, N. Y.*

DIE MENISKUSVERLETZUNG UND IHRE BEHANDLUNG (Injury to the Meniscus and Its Treatment). Walter Jehn. *Bruns' Beiträge zur klinischen Chirurgie*, CLXVI, 278, 1937.

The author reports eighty-three cases of injury to the meniscus. In establishing the diagnosis the following signs are of importance: (1) the spontaneous appearance of a cartilage in the joint space; (2) locking; (3) recurring effusion; (4) circumscribed pressure and spontaneous pain on bending or stretching of the knee. If, after three weeks of conservative therapy, locking, circumscribed pain with muscle weakness, and effusion persist, an operation should be performed. If operation is delayed too long, arthritis deformans develops. The operation consists of an S-shaped incision in the meniscus. The synovia is not sutured in order to permit drainage of the effusion into the periarticular tissue. The fascia only is sutured. No compression bandage is used. Active movements are allowed at the end of ten days and passive movements after fourteen days.—*Ernst Bettmann, M.D., New York, N. Y.*

DIE VENTRALE WIRBELKANTENFRAKTUR (RANDLEISTENABSPRENGUNG) UND IHRE BEZIEHUNGEN ZUR ADOLESZENTENKYPHOSE. [Anterior Fracture of the Margin of the Vertebra (Fracture of the Epiphysis) and Its Relation to Adolescent Kyphosis.] Walter Hetzar. *Bruns' Beiträge zur klinischen Chirurgie*, CLXVI, 345, 1937.

The author reports seven cases of fracture of the so-called vertebral epiphysis (*Randleiste*). He states that the pathology is due not to trauma alone, but to a combination of trauma with adolescent kyphosis. The latter causes the vertebral margins to have a tendency to separate, and, when trauma is added, the fracture occurs. The fracture line always lies in the vicinity of the portions of the vertebral spongiosa which are contiguous to the epiphysis.—*Ernst Bettmann, M.D., New York, N. Y.*

ABRISSBRUCH AM FERSENBEIN (Avulsion Fracture of the Os Calcis). Viktor Struppler. *Bruns' Beiträge zur klinischen Chirurgie*, CLXVI, 402, 1937.

There are authentic fractures of the os calcis due to tendon pull, which, however, do not appear to result from plantar flexion of the foot, but from marked hyperextension of the foot whereby the os calcis serves as a sort of pulley for the changing of the pull of the tendo achillis in the direction of the sole of the foot.

The author reports a case of maximum hyperextension of the foot without compression, caused by the patient's standing on the rungs of a ladder which broke, in which the upper part of the os calcis was torn out and the tendo achillis was ruptured.—*Ernst Bettmann, M.D., New York, N. Y.*

REGIONAL ANAESTHESIA FOR ORTHOPEDIC OPERATIONS. Charles F. McCuskey. *California and Western Medicine*, XLVIII, 179, March 1938.

The author presents a detailed description of cervical, brachial, and paravertebral blockings. As preliminary medication, a barbituric-acid and narcotic combination is recommended. The anaesthetic is made up fresh from a 20-per-cent. solution to the desired strength and a few minims of adrenalin are added.

Cervical block is obtained for laminectomy and reduction of fractures and dislocations by depositing the anaesthetic on the transverse processes in the operative region. The brachial plexus is blocked just above the middle of the clavicle and is used for operative work on both arm and shoulder. Paravertebral block is performed in the lumbar and thoracic areas for reduction of fractures and for fusion operations. Local anaesthesia provides increased safety, with reduction of operative shock and of pulmonary complications.—*Charles Lyle Hawk, M.D., Los Angeles, California.*

SULLE CISTI DEL MENISCO. CONTRIBUTO CLINICO. (Cysts of the Meniscus.) H. Wolff. *La Chirurgia degli Organi di Movimento*, XXIII, 18, 1937.

Six cysts of the meniscus, all involving the lateral cartilage of the knee, have been found at the *Istituto Rizzoli* during the past thirty-four years. The total number of

lesions of the cartilages encountered during this period was eighty. They were distributed equally between the sexes. The ages of the patients ranged from fifteen to forty, although thirty-three years represented the upper age limit for the initiation of symptoms. Trauma occurred in two of the six cases. The medial cartilage was never involved.

Localized pain, aggravated after walking or use of the limb, and difficulty in motions of the knee without any actual locking are common. Limping and swelling of the knee are unusual.

The cyst is best seen with the knee extended and disappears when the knee is flexed, according to the general opinion. This was true in two of the author's cases, whereas in one case flexion brought out the cyst better. In half of the cases, the position of the knee made no change in the appearance of the cyst. In one case the knee lacked only from 15 to 20 degrees of full extension.

In each case treatment consisted of excision of the cyst. Local anaesthesia was used, and in all but one case a longitudinal incision was employed. Follow-up examinations from one month to thirty-two years after operation showed no recurrences.—*A. W. Ciani, M.D., Iowa City, Iowa.*

THE REGENERATION OF OSSEOUS TISSUE. Zygmunt Ambros. *Chirurgja Narzadów Ruchu i Orthopedja Polska*, X, 223, 1937.

This extensive article, based on material observed on Dr. Gruca's Service, presents a detailed review of the literature followed by a clinical study.

The author states that bone transplants have a stimulating effect on bone regeneration, and that they also serve as a mechanical support. The implantation of a graft is followed by hyperaemia which accelerates the separation of diseased tissue and stimulates osteogenic proliferation. According to Leriche, from four to eight days after the transplantation a process of connective-tissue proliferation with neoformation of vessels takes place. There is an initial decalcification of the transplant along the haversian canals, which is followed by an osteogenic regeneration. In from six to eight months the transplant is adapted anatomically and physiologically to its new rôle.

If the reason for the transplantation is purely mechanical, as in the shelf operation of the acetabulum, heteroplastic transplants are considered best. The heteroplastic material is resorbed and transformed like the autoplastic material but it offers a better support. For the treatment of pseudarthrosis, the heteroplastic bone is also considered better. The femora of the turkey are utilized for this purpose.

Dr. Gruca's method of heteroplastic-bone implantation was used in the treatment of bone infection. It led to definite cure in a comparatively short time.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

AUTOPLASTIC AND HETEROPLASTIC BONE TRANSPLANTS. Zygmunt Ambros. *Chirurgja Narzadów Ruchu i Orthopedja Polska*, X, 345, 1937.

The author states that heteroplastic-bone transplants have been used on Dr. Gruca's Service since 1932. During this time, sixty transplantations have been performed. Beef bone and bird bone, from which fat and, occasionally, protein have been removed, have been utilized for osteosyntheses, shelf operations, fractures, corrective osteotomies, arthrodeses, and pseudarthroses. It has been found that there is no difference in regeneration between the heteroplastic bone and the autoplastic bone. In fractures and in shelf operations the results with heteroplastic bone were found to be better because of the simpler operative technique.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

LAS PARÁLISIS DEL NERVIO MEDIANO EN LAS FRACTURAS DEL CODO (Median-Nerve Palsy in Fractures of the Elbow). Vicente Sanchís Olmo. *Cirugía Ortopédica y Traumatología* (Madrid), I, 231, 1936.

Of 236 cases of fracture of the elbow, 12 per cent. showed signs of median-nerve lesion alone or combined with injuries to the radial or ulnar nerves. In eleven cases Volkmann's

ischaemic contracture was present. There were twenty-three cases of primary palsy which appeared during the eight days following the production of the fracture. Only four cases were observed in which secondary palsy occurred because of retraction of the superficial fascia or direct pressure by the bone. After the typical fracture (extension position), the sharp end of the proximal fragment injures and stretches the nerve. The treatment consists in removing the bone or fibrous tissues causing impairment of nerve function. Prophylactic measures, consisting in perfect reduction without forcible manoeuvers, are to be recommended.—*Francisco P. Dueño, M.D., Madrid, Spain.*

Operative and Conservative Treatment of Tuberculosis of the Spine. A Comparative Study. Harry Finkelstein, Benjamin B. Greenberg, Samuel A. Jahss, and Leo Mayer. *Journal of the American Medical Association*, CX, 480, Feb. 12, 1938.

A ten-year test was made by the authors to determine the comparative values of surgical and conservative treatments of tuberculosis of the spine. They reported the results of forty-three cases,—twenty-six were treated by fusion operations and seventeen by conservative methods. All of the patients were under twenty years of age.

The criteria for cure were as follows:

1. Pain, fever, muscle spasm, and body tilt must have disappeared for at least three months.

2. Abscesses must have disappeared, both clinically and roentgenographically, and sinuses must have closed.

3. Roentgenographically there must be seen increased calcification in the area of destruction, and cessation of all advance of the tuberculous process.

The average number of hospital days for those treated conservatively was 876; for those surgically treated, 1,215. The cases in which fusion was done, therefore, required about 40 per cent. longer hospitalization. Although the fusions themselves were successful, the pathological process in the vertebrae was apparently uninfluenced by the operation. Paraplegia developed in four cases following operation. In regard to an increase in deformity, no difference could be seen in the two groups. The condition progressed despite fusion.

The authors did find that the preoperative duration of the disease greatly influenced the hospitalization of the surgical cases. In cases in which the patients had had the disease six months or less before fusion, the average number of hospital days was 990; in cases of one to two years' duration, the average period of hospitalization was 1,210 days; and in those of over four years' duration, the average number of days was 480. It is suggested that fusion during the incipient stage of the disease would possibly alter the course of the disease. If early surgery is not done, then fusion should be postponed until the disseminative stage of the disease has passed and the patient shows positive signs of repair. The writers conclude, however, that tuberculosis of the spine is a chronic disease which runs its course little influenced by the orthopaedic surgeon.

Judged by the discussions, this article appears to have brought up a markedly controversial subject. In the discussions, the premises and the method of calculating the results are criticized. They also point out the facts that the fusion operation should not be used indiscriminately in all cases; its limitations should be respected; and end results are significant only in those cases in which surgery was unmistakably indicated.—*Harold M. Childress, M.D., Dallas, Texas.*

Sacro-Iliac Tuberculosis. Fred Thompson. *Journal of the American Medical Association*, CX, 1538, May 7, 1938.

The author reviews twenty-three cases of sacro-iliac tuberculosis which were treated by operative fusion.

All of the patients complained of preoperative localized pain which was greater

when standing and walking than when lying down. The average duration of symptoms prior to surgery was two and one-half years. The current so-called signs of sacro-iliac disease were absent as frequently as they were present. Sciatic pain seemed to appear most often in those cases in which abscesses were present. Preoperative diagnosis was not easy,—all had positive Mantoux reactions, and x-ray and laboratory studies did not give conclusive evidence. A positive Mantoux reaction confirmed, as a rule, a tentatively made diagnosis. Twenty-one of the operated cases had proved tuberculosis of the joint.

Arthrodesis was done through a posterior approach using grafts chipped from the ilium and sacrum. Soft-tissue abscesses were avoided when possible, but if in the field of operation they were excised or their walls were cauterized. A tight wound closure was made in an effort to procure primary healing. Primary closure occurred in 25 per cent. of those who had sinuses and in 41 per cent. of those in whom no sinus was present before operation. Draining postoperative sinuses developed in 52 per cent. of all the cases. In most instances the sinus closed in five months.

The average postoperative period in bed, for patients who had no demonstrable active tuberculous foci elsewhere, was three months. Others, with active pulmonary lesions, or with elevated temperature, pulse rate or sedimentation rate, were kept in bed until, clinically, the activity had subsided. This required, in some, up to three years. The clinical signs as noted above, and not the x-ray, were used to indicate when the process had subsided sufficiently to permit normal activity.

Mortality was 21 per cent., all deaths occurring within one year after operation.

The writer concludes that surgical fusion of tuberculous sacro-iliac joints results in cure of the local process.—*Harold M. Childress, M.D., Dallas, Texas.*

MERALGIA PARAESTHETICA. A REPORT OF ONE HUNDRED AND FIFTY CASES. Arthur D. Ecker and Henry W. Woltman. *Journal of the American Medical Association*, CX, 1650, May 14, 1938.

Meralgia (hip pain) paraesthetica is produced by changes in the sensory lateral femoral nerve. The authors report a study of 150 cases. They point out the exact course of the nerve, especially its angulation as it emerges from the pelvis, and its course beneath the fascia lata.

The condition appears to be due to a neuritis produced by a selective toxaemia or/and by trauma. Other probable causes are intra-abdominal and intrapelvic pressure on the nerve, and direct injury to the nerve as it lies in a fascial bed in the thigh. Middle-aged men are most commonly affected. Obesity may be an etiologic factor by altering posture, which would permit the inguinal ligament and fascia to exert pressure or traction on the nerve. Five of the cases had lesions affecting the nerve roots within the spinal canal. One of these developed bilateral meralgia shortly after the administration of a spinal anaesthesia.

Numbness over the anterolateral area of one thigh is usually the earliest and most frequently found symptom. Tingling, pain, and a burning sensation may also be present. These are more severe and persistent upon prolonged standing by the patient. The chances are good for spontaneous recovery if the symptoms have been present for less than two years.

Treatment is at first conservative. If the condition remains unimproved, nerve resection should be done.—*Brandon Carrell, M.D., Dallas, Texas.*

TUBERCULOUS FOCAL CHANGES ABOUT THE KNEE JOINT AS REVEALED BY ROENTGENOGRAPHY. V. P. Gratziansky. *Khirurgiya*, V, 122, 1937.

Between 1919 and 1935, 1183 cases were observed in the Institute of Surgical Tuberculosis. Of these 116 cases, or 9.8 per cent., were found near the knee joint. The hip joint was involved in 13.8 per cent. The frequency, localization, and configuration

of the isolated foci were studied. This was amplified by a study of their course, age group, and relation to other foci. The lower end of the femur was involved in 52.5 per cent., the upper end of the tibia in 40 per cent., and the patella in 7.5 per cent. The fibula was not found to be involved. It was frequently observed that even large foci with destruction were not apparent roentgenographically. The differential diagnosis was found to present certain difficulties.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

GOLD TREATMENT OF ARTHRITIS. A REVIEW OF 900 CASES. Stanley J. Hartfall, Hugh G. Garland, and William Goldie. *The Lancet*, II, 784, 838; 1937.

This report is based on a study over a four-year period of the results obtained from treatment by gold salts, both intravenously and intramuscularly. A review of 690 cases of rheumatoid arthritis treated by this method gave the following results:

Result	*Per Cent.*
Apparent cure	9.9
Marked improvement	56.8
Moderate improvement	13.0
Slight improvement	6.2
No improvement	8.9
Condition worse	2.5
Death (various causes)	2.7

One course of treatment consisted of an injection once a week for a period of twelve weeks. It was found that two courses of treatment gave the best results.

Improvement usually began midway through the first course. Experience showed that this treatment was most beneficial in rheumatoid arthritis, and the authors recommend its use only in this type.

The results of gold treatment in sixty-eight cases of osteo-arthritis are as follows:

Result	*No. of Cases*
Cure	0
Marked improvement	10
Moderate improvement	11
Slight improvement	19
No improvement	22
Condition worse	6

Toxic reactions were seen in 35.3 per cent., excluding very mild single reactions which would bring the total to 41.9 per cent. Toxic reactions are discussed in regard to type, prevention, and treatment.

Relapse may occur, especially after the first course, but, if treatment is continued, relapse is rare.—*Herbert T. Browne, M.D., Iowa City, Iowa.*

RUPTURE OF THE SUPRASPINATUS TENDON. C. H. Gray. *The Lancet*, I, 483, 1938.

The author reviews the subject of the treatment of partial and complete rupture of the supraspinatus tendon with a discussion of the anatomy, pathogenesis, and clinical features. He reports fifteen cases, twelve of which were associated with fractures about the shoulder joint. He finds that limitation of active abduction is a characteristic feature and recommends an exploratory operation where signs and symptoms persist, after an adequate period of conservative treatment.—*A. R. Shands, Jr., M.D., Wilmington, Delaware.*

TREATMENT OF CERTAIN JOINT LESIONS BY INJECTION OF LACTIC ACID. W. Grant Waugh. *The Lancet*, I, 487, Feb. 26, 1938.

The author has observed that there is a development of acidity in the traumatic effusions of joints, similar to that found in a primary hematoma surrounding a fracture. It has been assumed that the development of this acidity is a physiological response to trauma to excite local leucocytosis and repair. In an attempt to imitate this physiological reaction in joints, the author has injected a solution of lactic acid and novocain into the pathological joint in cases diagnosed as traumatic arthritis or recurrent synovitis. He believes that the injection of this solution of lactic acid and novocain hastens the return to normal function. He has also observed that the synovial fluid in rheumatoid arthritis shows an abnormal alkalinity and has injected the same solution into a number of these joints with subsequent improvement.

His conclusions are that in rheumatoid arthritis the possibilities of restoring function by the injection of lactic acid deserve further investigation, but for the present this method should be reserved for those cases showing severe disorganization of joints.—*A. R. Shands, Jr., M.D., Wilmington, Delaware.*

GOUT. Leslie C. Hill. *The Lancet*, I, 826, April 9, 1938.

The author has reviewed ninety-three of his own cases of gout over a three-year period. The following are the significant findings:

1. A family history of gout is obtained in about 50 per cent. of the ninety-three cases.
2. There is a strong suggestion that a high proportion of those cases in young people are secondary to nephritis.
3. Tophi are present in about half the cases.
4. There is a definite tendency for the initial attack to occur at night.
5. Spring is clearly the season of choice for gout, and autumn next.
6. A rapid return to normal following clinical improvement is a characteristic feature.
7. The blood uric acid is not always above normal. There is no essential abnormality of the blood urea.
8. There is no evidence in this series of a high blood calcium or of a glycosuria.—*A. R. Shands, Jr., M.D., Wilmington, Delaware.*

LE SYNDROME KOEHLER-PELLEGRINI-STIEDA (Köhler-Pellegrini-Stieda Syndrome). I.-N. Odessky. *Lyon Chirurgical*, XXXIV, 272, 1937.

In discussing this syndrome, the author points out that the shadow of increased density appearing at the upper medial corner of the medial condyle of the femur, while it is usually post-traumatic, is not present immediately after the injury; it changes its shape often during observation; and it is not continuous with the bone of the femur in many cases. It is often associated with increased density of shadow in the tibial collateral ligament. Fracture with a displaced fragment and periosteal osteophyte is, therefore, unlikely. It is a calcification and later, at times, an ossification of soft parts in the region, and may be associated with unabsorbed hemorrhage and callus formation. The treatment is non-operative conservative therapy.—*Robert B. Portis, M.D., Iowa City, Iowa.*

RÉSULTATS ÉLOIGNÉS DES BUTÉES OSTÉOPLASTIQUES DANS LES SUBLUXATIONS CONGÉNITALES DE LA HANCHE (Late Results of Osteoplastic Shelving in Congenital Dislocation of the Hip). Tavernier et Trillat. *Lyon Chirurgical*, XXXIV, 490, 1937.

The authors discuss the late results in forty-nine cases. The ages of the patients at operation varied from three to twenty-seven years. Most of the patients were near puberty, and only seven were over eighteen years of age. Twelve patients were operated upon for mild instability of the hip as a prophylaxis against true dislocation. Poor results and later dislocations occurred in five cases. In two cases stable but painful hips resulted.

Excellent results were obtained in five cases. Of twenty-seven cases with painful dislocations, perfect results were obtained in three; very good results in ten; fair in nine; and poor in five. The cause of the failures was attributed to poor shelving. The shelves were too small, or too high, or posterior to where they should have been, or oblique. In ten cases in which there were arthritic changes the results were inconclusive, as the patients were operated upon a long time ago when the procedure had not been perfected. In all patients over five years of age attempts to bring the femoral head into the acetabulum or near it resulted in postoperative arthritis with immobilization of the hip in the position of plaster fixation. This was painless, but accompanied by a progressive atrophy of the bone of the upper femur and acetabulum. In three or four years, however, the lesion began to regress, and remarkable recovery ensued. Eight such cases are mentioned.—*Robert B. Portis, M.D., Iowa City, Iowa.*

Die Differentialdiagnose der traumatischen oder spontanen Entstehung der Ruptur der langen Bicepssehne (Differential Diagnosis of Traumatic and Spontaneous Rupture of the Long Head of the Biceps Brachii). Fr. Gillitzer. *Monatsschrift für Unfallheilkunde und Versicherungsmedizin*, XLIV, 542, 1937.

Spontaneous ruptures are usually characterized by their occurrence high up on the tendon, often in the intertubercular sulcus. In contrast to this, the traumatic ruptures mostly occur near the myotendinous junction, even in the muscle itself. Whereas a hematoma is rarely found in a spontaneous rupture, it is almost always present in a traumatic rupture. The tendon is dull and usually frayed in spontaneous rupture, but in traumatic rupture it is glistening and the tear is clean-cut. Inflammatory signs appear in spontaneous rupture, but not in acute traumatic rupture.

Spontaneous ruptures occur almost always in persons over forty and most often in workers in certain occupations, such as glass-blowers, trip-hammer operators, trap-drummers, etc. These workers use their shoulders a great deal.—*J. Vernon Luck, M.D., Iowa City, Iowa.*

Treatment of Acute Suppurative Inflammation of the Knee Joint. P. I. Goloborodko. *Novy Khirurgichesky Arkhiv*, XXXVII, 696, 1937.

The following method of treatment is used in the Clinic of the Prof. Rose Institute for Postgraduate Study of Physicians. An x-ray study of the joint to establish bone involvement is made. An aspiration of the infected joint is performed, and the fluid is examined bacteriologically. The joint is then filled under pressure with 0.5 per cent. to 1 per cent. solution of novocain. Subsequently one cubic centimeter of a mixture of phenol (30 per cent.), camphor (60 per cent.), and pure alcohol (10 per cent.) is injected. The trocar remains *in situ* plugged with a sterile rubber stopper. The leg is placed in flexion on a splint. In two days the joint is again aspirated, and the fluid is examined. If there is no improvement and the bacteriology is the same, a wide arthrotomy proposed by the author is performed. Four incisions are made, through which the tibial collateral ligament is cut transversely, and the capsule and the external fibers of the gastrocnemius are resected. If the condition remains unchanged, a resection of the joint, proposed by Prof. Rose, is done. Two incisions are made,—one laterally between the iliotibial band and the biceps and one medially between the sartorius and the adductor magnus. The articular surfaces of the condyles and the tibia are widely resected through these incisions, and, if necessary, the synovial membrane is excised. The author claims brilliant results.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

L'Ostéotomie intertrochantérienne dans le traitement des pseudoarthroses du col du fémur (Intertrochanteric Osteotomy in the Treatment of Pseudarthroses of the Femoral Neck). V. Putti. *La Presse Médicale*, XLV, 1841, 1937.

Putti is of the opinion that the treatment of recent fractures of the femoral neck should include transtrochanteric osteosynthesis. Besides the age of the fracture and its type, the result of this osteosynthesis will be dependent upon the mechanical resis-

tance of the two fragments. Roentgenographic examination is the most dependable means of determining this capacity. Where the roentgenographic shadow is homogeneous in both fragments, the biological activity and the mechanical resistance of the fragments are the greatest. Where the head or neck shows a mottling or more diffuse bone absorption, the likelihood of successful osteosynthesis is questionable. In such cases, and in those in which pseudarthrosis is already present, Putti suggests transtrochanteric osteotomy.

The method of transtrochanteric osteotomy depends upon the elimination of the cervical angle and the displacement of the upper end of the distal osteotomized shaft, so as to support both the fractured head and the osteotomized portion of the trochanter. Depending upon whether or not the shaft has been displaced upward, the site of the osteotomy may be higher or lower, but, in any event, it must always be between the two trochanters. The procedure is carried out under local anaesthesia with the patient in dorsal decubitus. The affected leg is held in slight flexion, abduction, and internal rotation. The skin incision is made directly down on the outer side of the greater trochanter. The upper end of the femur is exposed subperiosteally and the bone is cut at the base of the greater trochanter. This brings the line of incision just above the level of the lesser trochanter. The incision must be directly at right angles to the axis of the femur, and the femur should be displaced medially sufficiently to bring the upper end of the distal fragment beneath both the head and the base of the greater trochanter. Plaster is applied after skin closure.

The author has operated upon twenty-one patients since 1930. There were four males and seventeen females. The age of the patients varied between forty and seventy-seven. One patient succumbed to an intercurrent infection three months after operation. In one case, the result was unsatisfactory, because of insufficient medial displacement of the osteotomized fragment. In all the others, the results were entirely satisfactory. The author insists upon the advisability of maintaining the limb in slight flexion during the period of healing, in order to facilitate function of the hip in flexion.—*Henry Milch, M.D., New York, N. Y.*

La radiothérapie du deuxième ganglion sympathique lombaire dans les coxarthries (Radiation of Second Lumbar Sympathetic Ganglion in Arthritis of the Hip). Duhem, Moro, et Montmignaut. *La Presse Médicale*, XLVI, 153, 1938.

Following the results obtained by Massart, after injection of the ganglion with local anaesthetics, the authors were inspired to effect similar results by radiation of the lumbar sympathetic ganglia. The area irradiated was ten centimeters square and was centered about three centimeters lateral to the mid-line, at the level of the second lumbar vertebra. The factors used were 180 to 200 kilovolts, with an intensity of three milliamperes, filtered through five-tenths of a millimeter of copper and two millimeters of aluminum at a focal distance of forty centimeters. The dosage was about 150 roentgen units at each of six treatments, given twice weekly.

Twenty-five cases were treated. In four cases, amelioration of the pain occurred after three treatments; in six, after four treatments; in eight, after six treatments. In cases where low dosage was employed, a second course of treatment, after the lapse of a month, was necessary. No statement as to the duration of the relief was made.

The authors believe the effect is obtained through a "functional ganglionectomy". The effect is merely to reduce pain and so to permit a greater range of motion in the affected joints. No change is, of course, to be expected in the roentgenographic appearance of the advanced lesions.—*Henry Milch, M.D., New York, N. Y.*

Bilateral Recurrent Dislocation of the Patella. J. D. B. Galloway and H. B. Macey. *Proceedings of the Staff Meetings of The Mayo Clinic*, XII, 783, 1937.

The authors report the case of a woman, forty-eight years of age, who complained of pain in both knees and outward slipping of both knee caps. At the age of six, the right

knee had gone out of place, and the knee cap had slipped to the outer side of the knee. In following years there had been many recurrences. When the patient was fifteen years of age, dislocation of the left knee had occurred, but the reactions had not been so severe nor subsequent dislocations so frequent as in the right knee. Slipping of both knee caps had occurred at increasingly frequent intervals, and for the past six or seven years the patient had never been entirely free from some discomfort. Some surgery had been done on the right knee fifteen years previously.

Examination disclosed a fixed lateral dislocation of the right patella. The left knee was normal, but, on flexion to 40 degrees, a spontaneous lateral dislocation of the patella occurred. Roentgenographic examination showed lateral dislocation of the right patella and abnormal lateral position of the left. Marked hypertrophic changes and evidence of several loose bodies in the knee joints were also seen.

Operation disclosed an osteochondritis dissecans of both medial femoral condyles and thickened synovial membrane. The quadriceps tendon in each knee was freed and reefed medially. The insertion of both patellar ligaments, together with a large fragment of bone, was transplanted to the medial aspect of the tibia after preparation of a suitable bed. Twenty-one days after operation the patient was able to be up in a chair.

The operative procedure described has been used thirty-seven times with only one failure.—*F. Polesky, M.D., Iowa City, Iowa.*

CONGENITAL BONE DYSPLASIA. Sylvester Ford. *Radiology*, XXX, 117, Jan. 1938.

Congenital bone dysplasias are divisible into two main growths,—the malacic, with deficiency in subperiosteal bone production and osteoporosis; and the hyperostotic, with overproduction of cortical bone. In the first group falls osteogenesis imperfecta, which has two forms,—the congenital and the late. Osteogenesis imperfecta congenita is characterized by multiple fractures showing evidence of healing *in utero*. The patients survive only a few hours. They are always born to normal parents. There is no abnormality in the blood chemistry of either patient or parents.

Osteogenesis imperfecta tarda, also called osteopsathyrosis and fragilitas ossium, presents fractures incident to minor traumata and involving the diaphyses of long bones and ribs, the majority occurring between the ages of three and eleven and rarely after twenty. These fractures heal rapidly, often with deformity. There is a high degree of osteoporosis, and the cortex is thin and deficient in lime salts. Apparently there is a non-hereditary type and a hereditary type which is part of a syndrome in which blue sclera are a dominant characteristic. Key applies the term "hereditary hypoplasia of the mesenchyme" to the latter. The blue sclera are always present both in the patient and in one parent. There is no skipping of generations. Associated with it may be: (1) multiple fractures; (2) deafness, of the otosclerotic type; and (3) loose joints and frequent dislocations. Treatment is symptomatic. Large doses of viosterol or of parathyroid extract are contra-indicated.

Osteitis fibrosa is considered a congenital bone dysplasia with strong hereditary tendencies.

Osteitis deformans is thought also to have hereditary tendencies.

Congenital bone dysplasias characterized by hyperostotic changes comprise a small group of rare conditions. Hereditary and familial factors appear to be definitely present. In this group are included marble bones, also known as congenital osteosclerosis and osteopetrosis. The changes consist in increase of hard cortical bone, with partial or complete obliteration of the marrow cavity. The condition is more or less generalized and occurs in the first age period.

Melorheostosis, or "flowing hyperostosis", is characterized by non-generalized proliferation of cortical bone along the shafts of the long bones of a single extremity and the disposition of irregular bony masses in the shoulder and the hip. The average age of onset is twenty years.

Osteopoikilosis, or "disseminated condensing osteopathy", shows small areas of in-

creased density in the spongiosa of the epiphyses and metaphyses, which have been demonstrated in all the bones except those of the skull. The condition is symptomless.

There is no evidence to show that the congenital bone dysplasias are manifestations of endocrine dysfunction. Studies of mineral metabolism have failed to elicit any conclusive results.

The author reports a case of osteogenesis imperfecta congenita in detail.—*Edward N. Reed, M.D., Santa Monica, California.*

ANOMALIES OF THE LUMBO-SACRAL SPINE. Paul C. Williams. *Radiology*, XXX, 361, March 1938.

While it has long been thought that an anomalous lumbosacral spine can produce pain, the cause of the symptoms remains controversial. A study of 1000 patients with low-back pain showed 30 per cent. with bony anomalies, 16 per cent. of which were so-called lumbarization or sacralization.

The other anomalies included imperfect fusion of the sacral lateral masses (7.75 per cent.), spondylolisthesis (3.25 per cent.), and facet fragmentation and anomalies (2 per cent.). Most of the patients presented both local and segmental symptoms. Segmental symptoms are due to degenerative changes produced by altered mechanics which cause an abnormal stress on the intervertebral disc.

Trauma may cause the appearance of these anomalies early in life; otherwise, they usually are not evident until middle life. With fixation of a transverse process on one side there is usually a subluxation of the articular facets on the opposite side, and thinning of the intervertebral disc. Subluxations of articular facets often lead eventually to proliferative changes with encroachment on the foramina of exit of lumbar-nerve or sacral-nerve roots and development of pain in the regions of their distribution.—*Edward N. Reed, M.D., Santa Monica, California.*

THE IMMEDIATE AND END-RESULTS OF RADIATION THERAPY IN CERTAIN BENIGN BONE TUMORS. Howard P. Doub, Frank W. Hartman, and C. Leslie Mitchell. *Radiology*, XXX, 420, April 1938.

In the earliest radiation treatment of benign giant-cell tumors of bone, sufficient dosage was given to produce skin erythema and a considerable reaction in the tumor. The subsequent tendency in dosage has been downward until at present a destructive reaction is avoided. The placing of radium in the cavity of these tumors is strongly advised against.

In several reported series of cases treated by x-ray, satisfactory results followed in from 50 to 100 per cent. A considerable number of cases have been reported in which apparently benign giant-cell tumors have undergone malignant transformation, the patients dying with metastases which proved to be osteogenic sarcoma. Coley estimated the incidence of this transformation to be about 15 per cent. This transformation is thought to be the result of various insults, in which curettage and imperfect irradiation probably played the leading rôles. Irradiation alone is thought by some to be able to cause malignant transformation. The fairly high incidence of osteogenic sarcoma in painters of radio-active watch dials, in areas which had previously been the site of radiation osteitis, is noted.

Solitary bone cysts have also been successfully treated by radiation alone.

The authors believe that roentgenotherapy and surgery should not be combined in the treatment of giant-cell tumors.—*Edward N. Reed, M.D., Santa Monica, California.*

CÁLCINOSIS INTERVERTEBRALIS. J. M. Muñoz Arbat y P. Piulachs. *Revista de Cirugía de Barcelona*, XI, 22, 1936.

The authors report a case of calcification of the intervertebral disc in a woman, forty-seven years of age, with an infantile lumbothoracic kyphoscoliosis. Percussion

from the tenth thoracic to the third lumbar vertebra elicited pain. Roentgenographic examination revealed calcification of the nucleus pulposus between the ninth and tenth thoracic vertebrae and between the tenth and eleventh thoracic vertebrae.

Besides the usual causes of the process (infection, age, and metabolic changes), there are two fundamental types: a degenerative type, common to old age, in connection with deforming spondylitic changes and without subjective symptoms; and an infectious type, found in young people, with clinical signs of severe pain, contracture, and fever. The anatomical changes of the disc (bony degeneration) in the first type remain unaltered; in the second type, the calcareous deposit disappears as soon as the clinical symptoms subside. Roentgenotherapy, rest, and some form of heat are recommended to lessen pain. Severe cases will be benefited by the Albee operation.—*Francisco P. Dueño, M.D., Madrid, Spain.*

RUPTURE-LUXATION DE L'APPAREIL EXTENSEUR DES DOIGTS AU NIVEAU DE LA PREMIÈRE ARTICULATION INTERPHALANGIENNE (Rupture-Luxation of the Extensor Apparatus of the Fingers at the First Interphalangeal Articulation). R. Montant et A. Baumann. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur*, XXV, 5, Jan. 1938.

This is a most interesting and detailed study of the extensor apparatus of the fingers. The anatomy of this apparatus, based on personal investigations, is described and the mechanics of extension is adequately explained.

A rupture-luxation of the extensor apparatus causes a typical deformity of the finger,—namely, extension or hyperextension of the proximal phalanx, flexion of the middle phalanx, and hyperextension of the distal phalanx.

The treatment of this lesion consists in uniting the medial band of the extensor which is torn and restoring the triangular portion between the lateral bands of the extensor apparatus, or, in case of difficulty, in suturing the two lateral bands in the middle over the medial band.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

CHONDRODYSTROPHIE AVEC ÉLARGISSEMENT ET DIMINUTION DE HAUTEUR DES VERTÈBRES (PLATYBRACHYSPONDYLIE). [Chondrodystrophy with Widening and Diminution in Height of the Vertebrae (Platybrachyspondylisis).] R. Guérin et A. P. Lachapèle. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur*, XXV 23, Jan. 1938.

The authors suggest that the term "platyspondylisis" should be applied only to cases when widening of the vertebrae is observed; that the term "brachyspondylisis" should be given to cases in which there is a decrease in height of the vertebrae; and that "platybrachyspondylisis" should be confined to cases in which the vertebrae are widened transversely and diminished in height.

In a case observed by the authors, the changes in the spine were only a part of a generalized affliction of the osteocartilaginous apparatus. There is no pathologico-anatomical basis for classification of this disease. However, the four cardinal elements present (general habitus, symmetry of lesions, localization in the spine and bones of enchondral origin, and the site of the disease at the locus of bone growth) permit this condition to be placed among the chondrodystrophies. The authors suggest classifying it as a familial chondrodystrophy with brachyspondyly.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

CHIRURGIE DES MAINS BOTES TRAUMATIQUES (Treatment of Traumatic Club Hands). M. Oberthur. *Revue d'Orthopédie et de Chirurgie de l'Appareil Moteur*, XXV, 56, Jan. 1938.

An operative procedure is described and satisfactory results are reported. In a case of malunion after a badly comminuted fracture of the lower end of the radius, involving the radio-ulnar joint, with complete loss of pronation and supination, accompanied by pain and deformity, the following technique was used:

1. Longitudinal incision between the flexor carpi ulnaris and the extensor carpi ulnaris with resection of one inch of the ulna.

2. Removal of cartilage in the radio-ulnar joint and introduction of a wooden screw to hold the radius and the ulna.

3. Suture of the pronator quadratus to the tendon of the extensor carpi ulnaris.

4. Subsequent cuneiform osteotomy of the radius and removal of the wooden screw, followed by immobilization in plaster for two months.

This procedure resulted in restoration of supination and of pronation, correction of the deformity, and only slight limitation of flexion. It should be used in adults only.—*Emanuel B. Kaplan, M.D., New York, N. Y.*

THE TREATMENT OF CONTRACTURES AND ANKYLOSIS OF TUBERCULOSIS OF THE KNEE. B. Špišić. *Slovanský Sborník Ortopedický*, XI, 307, 1937.

Of 370 cases of joint tuberculosis, seen on the Orthopaedic Service at the University Clinic in Zagreb during the past six years, 101 involved the knee. The flexion contracture of this joint is now treated by the author primarily with the turnbuckle cast and the Quengel attachment. By this method almost all of the contracture can be corrected in from eight to fourteen days. Should some contracture remain or be associated with valgus, varus, or subluxation deformities, a para-articular osteotomy completes the correction.

In a series of 300 cases of tuberculosis of the knee, seen during the past fifteen years, two arthroplasties have been performed. The first patient was a male, twenty-one years old, with bilateral ankylosis,—one knee was ankylosed in 180 degrees and the other in 85 degrees. Proof of tuberculosis or length of time since quiescence are not stated. Both knees were reconstructed with satisfactory results. The second patient was a female, twenty-two years old, with ankylosis in flexion and valgus from a childhood tuberculosis. Eighteen months after arthroplasty of the knee, 60 degrees of motion was present.

The author states that a favorable outcome usually follows the use of the proper technique in a patient with good musculature if the limb is immobilized in a hip spica for four weeks after operation and then fitted with a long leg brace to relieve weight pressure. Physiotherapy apparently plays a minor part.—*W. R. Hamsa, M.D., Iowa City, Iowa.*

TOTAL TENDON TRANSPLANT FOR SLIPPING PATELLA. A NEW OPERATION FOR RECURRENT DISLOCATION OF THE PATELLA. Emil D. W. Hauser. *Surgery, Gynecology and Obstetrics*, LXVI, 199, Feb. 1938.

The author discusses the etiology of slipping patella and reviews the literature and various methods of treatment.

He then gives the technique of his own operation. The patella, conjoined tendon, and patellar ligament are adequately exposed by a curved incision, beginning well above the patella, curving around its lateral aspect, and then coming back to the mid-line about a half inch below the tibial tubercle. The patellar ligament is dissected free down to its insertion. A block of bone about one-half an inch square, including the attachment of the patellar ligament, is removed from the tibia. The entire lateral side of the patella is then freed by dividing the fascia down to the capsule. The dissection is next carried along the lateral side of the conjoined tendon well up into the area of the fascia, lateral to the vastus lateralis. The fascia is divided down to the capsule, but the operation remains extra-articular. The patella is then drawn medially by means of the patellar ligament which is buried in a previously prepared bed in the tibia. Over this the periosteum is sutured. The cavity of the old bed of the tibial tuberosity is filled in with bone removed from the prepared bed.

A number of cases are presented. The results have been uniformly good.—*P. F. Siman, M.D., Iowa City, Iowa.*